THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

THE NINETY-FIFTH GENERAL MEETING of the Institution of Petroleum Technologists was held in the rooms of the Royal Society of Arts, John Street, Adelphi, London, on Tuesday, October 12, 1926, Mr. ALEXANDER DUCKHAM, F.C.S., Vice-President, occupying the chair in the unavoidable absence of the President.

The Secretary read the list of new Members elected since the previous meeting, as follows :—

Members.—Frank Laurence Bassett, Harold Fordyce Crooks, Andrea La Porta, Louis John Le Mesurier, Geoffrey Hindmarsh May, Traian I. Metianu, John Robert Suman.

Transferred to Member.—John Nicholson Hazeldon.

Associate Members.—Thomas James Freeland Armstrong, Kenneth Edgar Clayton-Kennedy, Arthur James Davis, William Eric Frankenburg, Frank Leslie Garton, Leonard Gower, John Henry, John George Alexander Jeffrey, Felix Kortlandt, Wallace Gordon Lindsay, Charles Murray Pollock, Charles Barnett Wingfield.

Transferred to Associate Member.—Maung Ba-Yan, Arthur Edmund Corbet Cooke, Rollo Hillyard Stafford Haydon, Francis Roger Spencer Henson, Hubert Kildare Long, Maurice Arneil Rust, Yvor Patten Wilson.

Students.—Randle James Bramhall, Thomas George Kidd.

Associates.—Eric Aspinall, Cecil Chilvers, Harold Hopwood Goldthorpe, John Stuart Smith, Richard Llewelyn Wilson.

Transferred to Associate.—Bernard Ian Richardson, Francis Erskine Gordon Watson.

The Secretary reminded the Members that nominations for Members of Council should be in his hands not later than January 31 next.

The following paper was then read :—

The Significance of Surface Oil Indications.

By A. BEEBY THOMPSON, O.B.E., M.I.Mech.E., M.Inst.M.M., F.G.S. (Member).

I. INTRODUCTORY.

To those of us who have had to deal with the exploratory and consulting side of oil technology there is no term which covers a wider range of meaning than the phrase "oil indications." Even apart from the non-technical man, who cannot be expected to place a true value on the different types of phenomena associated with

potential oilfields, it is surprising what a diversity of opinion is still expressed in technical reports on the interpretation of the different types of oil indications.

It seemed, therefore, that a short paper on this subject, and especially on misleading indications, might form the basis of an interesting discussion.

If America is excepted, it may be said that almost every important oilfield of the world has been marked by surface manifestations, often of a striking character. Even in America, most of the oilfields of Tertiary age, and many of Mesozoic and Palæozoic age, betrayed surface evidences of oil. There are, however, such numerous instances where oil manifestations have led to no discovery of oil in commercial quantities, either locally or regionally, that a consideration of the importance of various kinds of "shows" should prove useful. Initial interest in new districts is nearly always stimulated by surface indications of oil in some form, and there are many geologists of distinction who have declared that they would hesitate to recommend drilling on any structure near which no evidence of oil had been recorded either on the surface or from wells.

Twenty years ago it was easy to name scores of unprospected, accessible places where well-known surface manifestations justified prospecting activity. To-day difficulty would be found in naming half-a-dozen reasonably accessible spots, which had escaped the attention of oil scouts or geologists, and each year less and less encouraging signs of oil become the object of detailed investigation. The significance of surface "shows" has, consequently, every year increasing importance, as the time has not yet arrived for indiscriminate drilling on geological structures regardless of other factors, although something approaching this is being witnessed in parts of America, where so many surprises have rewarded the activities of the venturesome if incautious.

In assessing the value of surface manifestations the age of the strata and their lithological characteristics must be taken into account. Almost invariably oil measures of Tertiary age are accompanied by much more pronounced indications than Cainozoic or Palæozoic oil measures, but in those cases where Tertiary strata are consolidated and cemented as in Burma and Peru, thus more closely approaching the character of the older rocks, the "shows" may closely approximate in extent and nature those connected with the older rocks.

Few technologists with widespread experience of oil exploration could have failed to meet with perplexing manifestations of oil admitting of no simple explanation. At times it becomes difficult for a conscientious worker to decide whether the indications

justify the expense of detailed surveys or even of prospect drilling, yet he must make up his mind in order to advise his clients or principals on their line of action. It is only occasionally that one can positively assert that prospecting can be prosecuted with the absolute certainty of striking oil in commercial quantities or, on the other hand, to affirm, where the evidence is largely negative in character, that no oil would be found. As a rule the evidence has to be carefully sifted and a qualified recommendation may have to be given.

In this paper it is proposed to describe some of the manifestations which have in some cases led to the development and, in others, to the abandonment of certain regions.

Surface indications may be tabulated under several general headings, viz. :—

1. Seepages of oil and asphalt deposits.
2. Gas issues and mud volcanoes.
3. Bituminous rocks.
4. Native bitumens.
5. Salt and sulphur.

Seepages of Oil and Asphalt Deposits.—Seepages of oil are obviously direct and positive evidence of the existence of oil, and if the quality of the oil is acceptable—with due allowance for its environment—and they occur amidst conventional geological conditions, their importance cannot be questioned. Where oil seepages occur near the crest of broad anticlines or near the apices of domes, as so often is the case, their importance has always been appreciated. As a matter of fact, seepages of oil have betrayed the presence of most of the great oilfields of the world, including those of Russia, Mexico, Persia, Burma, East and West Indies, Venezuela, Columbia, Roumania and Galicia, whilst in the United States interest was attracted to most of the Californian fields by seepages as well as many in the Mid-Continent and the Gulf Coast.

Occasionally a very small seepage is sufficient to determine a course of action, as was the case in the Punjab, where on the Khaur dome, near Rawalpindi, a single seepage undisclosed by the natives gave the only direct clue as to the presence of oil. The structure had long been known, but no oil manifestations had been found in the district until this single seepage was accidently discovered. The same may be said of the Tabaquite Oilfield, Trinidad, where a single seepage on the crest of a fold gave the only clue to the existence of oil. This seepage subsequently proved to be in the richest part of the whole field, and had the initial well been carried to the deeper sands, later found to exist,

this pioneer well would probably have been the most prolific on the field.

It can be positively affirmed that the oil discoveries of recent years in the following countries can be traced almost entirely to the lead given by seepages of oil:—

Mexico.	Mesopotamia.
Venezuela.	Trinidad.
Colombia.	Emba-Caspian District,
Persia.	Russia.

Some light oils apparently reach the surface in an almost unaltered state, but usually seepage oils have suffered loss of light products and been subjected to inspissation by oxidation and polymerisation when coming into contact with air and Meteoric waters which have gained access to the strata. Seepage oils, consequently, often partake rather the appearance of asphaltic residues, and their viscous character causes them to cling to the surface of the ground and resist removal by rains. They are often rendered more viscous by contamination with earthy material collected in movement and by admixture with vegetable matter.

So thick are some seepage oils of a typical asphaltic nature that bubbles raised from cones by gas burst only with difficulty, producing miniature explosions. At other times ribbons yards long of black asphaltic material can be twisted round a stick which has been thrust into their midst.

Some of the seepages of asphaltic oils form, in time, large accumulations of solid substances on the surface and, indeed, cover acres of ground creating a deceptive idea of their extent. Rarely do these accumulations reach any considerable thickness, and much money has been lost in attempts to exploit commercially deposits ultimately found to have no useful depth.

Under certain peculiar conditions, as in the case of the so-called Pitch Lake of Trinidad and the Bermudez Lake of Venezuela oil seepages have collected in depressions and so led to the preservation of considerable quantities of asphaltic material. Probably somewhere between 5,000,000 and 10,000,000 tons of petroleum went to form the contents of the Trinidad Lake and its overflow past La Brea to the Gulf of Paria. The "pitch" is in reality an emulsified product with 29 per cent. of water and 25 per cent. of mineral matter.

There is apparently no present-day addition of asphalt although at one point a little gas and sulphur water still oozes through the mass. The level of the lake has fallen over 15 feet since it was worked and this fall corresponds closely with the amount of pitch

extracted. The removal of some 150,000 tons annually is causing a fall of level of nearly one foot annually.

At Bermudez the Lake occurs in swampy ground near sea level and there are signs of present-day exudations. The contents would appear to approximate 5,000,000 tons of asphalt mixed with 10 to 46 per cent. of water and 0·5 to 3·6 per cent. of mineral matter.

Nowhere elsewhere have such accumulations of petroleum residues been discovered, but quite large deposits are to be found in the Island of Sakalin, in other parts of Trinidad and Venezuela, and in Columbia, California, Borneo and near the Baku oilfields where oil strata outcrop. The Mexican seepages call for especial notice owing to their frequency and extent. Many occur near dykes of intrusive igneous rocks and it is an interesting fact that in a number of cases oily matter can be found in the interstices of the igneous rock. Some of the Mexican coastal belt seepages are miniature asphalt lakes and it is doubtful whether animals or men sinking a few feet into the mass could be saved. They are mostly "live" seepages where thick viscous residues fill depressions the depth of which has not been ascertained in most cases. It may be that at times they reach a considerable depth as they appear to be associated with a source of oil usually found at a depth of about 2,000 ft. In any case no useful supplies of oils have been found at less depth than the Cretaceous limestones and the seepages near favourable structures directed the operations of oil producers. In one or two cases craters were observed in the oilfield belt, where there had evidently been a fairly powerful blow-out at some time, due doubtless to gas accumulations beneath the asphalt.

Excellently preserved remains of animals have at times been found in seepages, but that of the Hancock ranch, Los Angeles, has proved the richest yet discovered. About 300 complete skeletons of extinct and living animals were taken from an area of about 20 acres, and distributed amongst scientific institutions in America.

Some light oil seepages are remarkable for their activity and size. The Lizard Spring seepage of Trinidad exhibits the unusual spectacle of a very light density oil issuing from steep-dipping fissured rocks accompanied by much gas which burns readily on ignition. The discharge appears to be continuous at all seasons of the year, and in the dry season large quantities of the oil accumulate in pools along the dry bed of a stream. Similar large seepages of light oil have been reported from Venezuela and Colombia, but as a rule the seepages are not so localised, but are distributed as oozing over fairly wide areas. Seepages occur on a large scale in parts of Alaska, and in the Gold Bay district the peaty deposits,

reaching a depth of 3 to 10 ft., are so saturated with oxidised oils that the material can be burnt as fuel. Only at Katalla has a small field been proved, and generally the strata is too disturbed for the formation of oilfields. Seepages of oil are especially abundant in the East Indian Islands where most of the oilfields of Sumatra, Java and Borneo owe their discovery to these surface manifestations along the crestal part of anticlinal folds. Seepages of exceedingly light oil are very common in parts of Italy where, however, only several small fields have been brought to light, due generally to disturbed conditions.

At times there is a bewildering distribution of seepages the origin of which is concealed by surface alluvium or thick beds of soil. When they assume no regularity it may be necessary to carry out geological studies for a long distance around. In many cases, however, the belts of seepages will be found to follow definite lines which give a clue to underground structure. Seepages are often very prominent where there are compressed isoclinal folds repeatedly bringing one or several oil sands to the surface. Those of Barbados, the Punjab, and some parts of the Caucasus, like Chatma, are characteristic of this type.

As an instance of the value of seepages, where all useful geological information was concealed by surface alluvium, may be mentioned the Ural-Emba region of Russia, where large flowing wells were obtained at several places after a little orderly prospecting with drills under geological guidance.

Gas Issues and Mud Volcanoes.—Issues of gas may be quite unconnected with oilfield phenomena and unless the gas has a pronounced petroliferous odour or issues from inflected strata or formations known to betray evidences of oil locally or regionally, it should not be assumed to be related to oil. At times faint traces of gas either odorous or inodorous have the greatest significance when other kinds of evidence are absent. Thus the only positive evidence of the existence of hydrocarbons in the Hurghada oilfield of Egypt was an odorous limestone although the surface structure was well defined and promising in appearance.

Methane, the most common gas met with in oilfields, and the most usual one found associated with oil measures, is inodorous, but it is often sufficiently contaminated with sulphur compounds or other hydrocarbons to divulge its presence. So much sulphur is present in some of the gases escaping from oil measures that by interaction with mineral salts and hydrocarbon gases considerable quantities of native sulphur are precipitated under suitable environment.

Those who were associated with early Russian oilfield development will recall when the gas issues of Surakhany, Baku, were regarded

as curiosities by sightseers, and the Parsee temple there was the object of pilgrimages to the Eternal fires. At that time some of the local Tartars excavated shafts into the fine-grained dark sands and employed the issuing gas for burning lime. A few years later this neglected area became one of the chief producing fields of Baku. At that time the significance of the gas was quite unappreciated by all of us engaged in the industry.

The existence of a gas issue on the crest of the Huntingdon Beach dome, California, was probably the determining factor in securing not only the development of this great field, but of the other famous Los Angeles basin oilfields.

It has been authoritatively asserted that in every one of the important coastal belt oilfields of Texas and Louisiana there were issues of gas often accompanied by supplementary manifestations. Sulphurous and Saline waters and seepages of oil in some cases afforded additional encouragement for prospecting. Nevertheless far more Gulf Coast salt domes have failed to yield commercial supplies of oil than those which have, and an American writer has stated that between 1917 and 1925, no less than $20,000,000 had been spent on 675 unsuccessful test wells in search for oil on salt domes in the Gulf Coast region of the United States.

Considerable volumes of gas escape from some of the oil seepages and keep the little pools of accumulated oil in a state of ebullition. In arid regions gas issues are not readily observed and may entirely escape notice when there is no water present. Cases have been recorded where animals have lost their lives through asphyxiation when gas has accumulated during still weather in depressions. Sometimes gas escapes incessantly from cracks spread over a few acres of ground, and until ignited it may be quite unobserved. At one spot in the Puta Valley near Baku, known as the Eternal Fires, the gas was always burning where it emerged from a series of holes in the ground. At Chittagong something similar is said to exist. At one spot in Trinidad, where an anticline crosses a main road, the surface is being constantly destroyed by issues of mud and gas.

Besides the constant issues there are sporadic outbursts of gas sometimes occasioned by earthquakes. In the Baku district large holes are formed from which belch forth great volumes of gas which usually ignites producing a brilliant spectacle at nights. These discharges often continue for days.

The occurrence of gas, even in large quantities, does not always indicate the presence of oil, although it is rare that one can discriminate between gas derived from an oil source and that from a purely gas source. In both the Eastern and Mid-Continental oilfields of the U.S.A. gas only has been found on folds equally

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suitable in all respects for oil concentration. The Monroe gas field of Louisiana, 325 square miles in extent, and the Kissarmas region of Transylvania may be cited as conspicuous examples where no oil has been found.

Mud volcanoes only occur where argillaceous strata predominate, and are mainly confined to regions where oil measures of Tertiary age are developed. Several distinct types are met with in Nature. The most common type consist of conical mounds built up of solidified mud, at the summit of which there is a central crater of muddy fluid kept agitated by gas. At intervals the mud overflows the edge of the crater and runs down the side, during which time the moisture is often evaporated, leaving either a moist or cracked surface of clay.

A second class consist of large craters of thin liquid mud, often of unfathomed depth, where the fluid is kept in constant ebullition by gas. As a rule gas rises in large volumes from one or more points in the basin, and a nearby stream conducts away the overflow.

A third variety assumes only sporadic activity. Between intervals of violence there may be long periods, even years of complete quiescence. With little or no warning the ground will commence to heave over a wide radius until with eruptive force the central part of the disturbed area will burst and be followed by the expulsion of masses of clotted clay. Enormous volumes of gas then discharge into the atmosphere and continue until momentarily checked by inflowing mud. This in turn is flung into the air, and in time acres of mud accumulate, burying whatever lies in the path of their flow.

Evidence of fossil mud volcanoes are to be found in some countries. Both in Trinidad, Barbados and Colombia disorderly masses of mixed debris comprising fragments of many geological horizons have been noted in the oilfield regions, and appear to be the remains of old mud volcanoes, and on the Apsheron Peninsula the eroded section of an old time mud volcano has been observed at Zykh. The old crater is filled with consolidated mud, and around the top were found fragments of rocks derived from geological horizons up to 5,000 ft. in depth. Solidified mud veins have also been observed on some of the structures in the Burma oilfield region, evidently the relics of past mud-volcano action.

Very rarely are mud volcanoes found in productive oilfields, although they may occur along the same flexure. They are generally met with on anticlinal folds in which oil-bearing rocks are involved, where the beds are much fractured or disturbed as a result of sharp flexuring, faulting or deflection from a general direction. Whilst demonstrating the presence of gas and some-

times oil, the areas in which mud volcanoes occur are usually distrusted as indicators of local oil by petroleum geologists. The one conspicuous exception known to the writer, of a mud volcano occurring in the midst of a major oilfield, is the case of Baku, where work on the reclaimed area of the Bibi-Eibat Bay has proved the existence of a vast mud volcano beneath which oil yielding strata have been struck. Evolution of much gas from the sea in this region had long indicated the existence of something unusual, but until actual drilling was undertaken it was assumed that the gas escaped from oil strata known to outcrop in that direction. It is, however, likely that the mud volcano indicates fault conditions which may be reflected in the lower yields of this area than elsewhere near the crestal zone.

A small mud volcano is to be seen near Balakhany Village, on the edge of the oilfield where the oil strata outcrop, but it more nearly approaches a "pitch" cone in character than a mud volcano, although a little gas-agitated muddy water is seen. Elsewhere in Russia, away from oilfields, enormous mud volcanoes are to be seen. Those of the Kertch and Taman Peninsulas attaining the proportions of large hills, but payable oil has never been located although much drilling has been undertaken. Sara attributes this state to the general absence of sands or other beds suitable for oil reservoirs at this end of the Caucasus, and it is likely that mud volcanoes are often concentrated in disturbed belts where plastic oil-bearing clays predominate and there is a paucity of sands. The ejecta of mud volcanoes is generally well puddled clay with little sand, but during violent outbursts numerous fragments of rock are often expelled with the mud.

The greatest mud outbursts both on land and beneath the sea have been recorded from the Arakan Islands off the Coast of Burma, on the Klias Peninsula, Borneo, and in Trinidad. In each of these localities sufficient mud has been ejected within a few hours or days to cause hills on land and islands to emerge from the sea. Frequently the escaping gas which has caused the eruption ignites and causes a flame, the glare of which can be seen for many miles around.

A spectacular mud volcano is to be seen at Minbu, Burma, on the crest of the Minbu fold but some distance from any productive well. At Berca, Roumania, there are some fairly extensive mud volcanoes near which payable productions of oil have never been found.

Bituminous Rocks.—Few countries could be named where rocks containing bituminous matter are not to be found. Usually they exist under such conditions that any connection with free oil deposits can be ruled out of consideration. At other times they suggest the possibility of oil occurring

at depth under favourable structural conditions. Both sandstones and limestones are found impregnated with bituminous material, but only occasionally does the degree of saturation warrant their designation of oil sand. Bituminous rocks are usually stained brown or black, and the impregnating material may be solid or liquid. Some of the rocks yield a strong odour of petroleum, others only emit an odour when struck or heated. Sands impregnated with a black oily residue are often referred to as "tar" sands in contradistinction to "oil" sands, which are brownish and saturated with a less polymerised oil. Obviously "tar" sands are true oil sands in regions where heavy asphaltic or naphthenic oils prevail.

Bituminous limestones are so common that only under special circumstances can they be regarded as favourable indicators of oilfields. So heavily saturated with oily matter are some limestones that they must command respect; such, for instance, as the rocks of Nebu Musa, in Palestine, and Makarum in Syria, where they have been burnt as fuel. Limestones are, however, such a convenient medium for the transfusion of fluids from neighbouring shales that this aspect must be kept in mind when considering their relationship to oil deposits.

Sands and sandstones impregnated with oily matter call for more serious notice, as if interbedded with clays or shales they might, under suitable structural conditions, contain accumulations of oil and gas. That richly impregnated sands cannot always be regarded as a sure indication of commercial oil in a region is illustrated by such examples as Spain, Madagascar, Nigeria, Angola and Canada. Much deep drilling has been undertaken on structures in Spain where bituminous rocks abounded, but with no encouragement, although some sands were heavily saturated with liquid, if much inspissated, oils. Madagascar has attracted considerable attention on account of the many and imposing outcrops of black bituminous sandstones in the Sakalava Valley, where seepages and gas issues gave additional encouragement. Hitherto drilling has failed to locate any useful supply of oils, possibly in consequence of an absence of sufficiently favourable structures.

Both in Nigeria and Angola drilling has been attended by negative results, although undertaken under the guidance of experienced geologists after extensive preliminary surveys. The tar sands of Alberta have for years been the object of world-wide comment, and no generally-acceptable explanation of their origin has yet been formulated. Scores of geologists have visited the Athabasca River region, and much test drilling has been carried out on folds, but without any striking success. Some oil and much gas have been struck in a few wells drilled on anticlinal folds.

Imposing outcrops of oil-saturated sands attracted attention to the oil measures of California, Baku and Cheleken, Russia and Trinidad, and in many other countries exposures of oil-stained sands have indicated the direction for geological study. At times where light-density oils prevail it may be difficult to recognise an outcropping oil sand. This was especially the case in Peru, where it was often necessary to excavate some feet into a suspected outcropping oil sand before the distinctive odour of petroleum was noticed. It has been found an advantage on some surveys to carry a small bottle of some solvent like chloroform, petrol or carbon bisulphide with which to test suspected sands. Often iron-stained sands closely simulate oil sands in appearance and can be mistaken without a test with solvents or heat. The upper sands of the oil-bearing series outcropping at Daga Shabell, Somaliland, were only recognised by treatment with solvents.

Where sands are found stained with oil, and they have the distinct odour of petroleum they must always be regarded as a favourable indication and the geology of the district should be closely studied.

Bulgaria furnishes an example of perplexing oil manifestations which at first seemed very difficult to explain. At a number of localities patches of black, odorous, bituminous rocks are to be found outcropping on the foothills of the mountains. So richly impregnated with viscous oil are the rocks at several spots that under the influence of the sun's heat the contained substances run, and form cakes of pitch-like material on the surface.

In some instances the rock is simply stained and not blackened, and again at other places all joint cracks for some distance show a dark film of bituminous material. Even the slightly-stained rock yields a distinct odour on heating or on breaking a sample, but the rich black material burns freely on ignition emitting dense black smoke. When blasted the odour can be detected for a long distance. At one place near Rakmanlare ancient pots set for firing showed that these rocks had been treated for the recovery of the contained oils. The rock in which the bituminous matter occurs is in all cases plutonic in nature and it was obvious that the oil could not have been formed in situ.

The main geological features of the regions were moderately clear. Wide valleys separate ranges of mountains which follow a general E.W. direction. The central part of the ranges is composed of igneous rocks (granite, porphyries, syenites, etc.) and occasionally on the flanks are steeply dipping Cainozoic or Palæozoic rocks. At other places metamorphic (gneisses, quartzites, etc.) and igneous rocks extend right into the valley until covered by

the practically horizontal Tertiary deposits which are found in most of the wide valleys between the mountain ranges.

All beds except the Tertiaries appear to have suffered inflection, but although some weeks were spent in covering large areas of ground no sedimentary beds of a bituminous or petroliferous character were observed such as might have accounted for the presence of oils in the igneous rocks. It was quite clear that the oil did not originate from the rocks in which it was found, and diligent search was made for beds from which it might have migrated. At several places oil shales were found, and it was known that oil shales occurred elsewhere in Bulgaria. These were ruled out of consideration owing to the peculiar character of the oil impregnating the rocks.

As no other probable source of origin for the oil could be found, the conclusion was drawn that it was derived from the distillation of lignitic material or coal by the intrusive igneous rocks, and that these sedimentary beds had later been removed by denudation. At one spot in the Pindop district carbonaceous beds are to be seen interbedded with mica schists, through which broad dykes of igneous rocks intrude. In close proximity to one of the dykes, which cut through the schists in a direction obliquely to the strike of the beds, a highly-impregnated patch of bituminous rock was noted. Only towards the end of the investigation in the district of Kostenetz was the satisfaction obtained of substantiating this view when a visit was paid to an outcrop of oilstained igneous rock some distance up a mountain gulley. Here the rocks are discoloured and distinctly bituminous, and directly in contact with them is a steeply tilted and disturbed lignitic band, the fringe of which in direct contact with the igneous rock, is carbonised. The smaller degree of saturation than elsewhere is probably due to the absence of brecciated material as is commonly associated with other exposures elsewhere.

Prof. Cullis, who kindly examined the samples at the Royal School of Mines, describes the rocks as essentially plutonic in character, being acid granitic pegmatites in which the bitumen fills cracks and interstices between the quartz and felspar crystals. The rich samples consisted of brecciated material, mainly angular quartz or felspar fragments cemented together with the bituminous material. They are thought to represent fault breccias or even scree such as the local circumstances suggested.

The writer is indebted to Mr. Wolf of the Imperial College, for undertaking an examination of the bituminous material impregnating these rocks. He describes his results as follows :—

The extracted bitumen was examined chiefly with a view to determining whether it was a natural asphalt formed by the

metamorphism of crude petroleum at comparatively low temperatures or a pyrogenous product formed by the natural destructive distillation of non-asphaltic pyro-bitumens (*e.g.*, coal or lignite) by intrusive igneous rock.

The freedom from "free carbon" particles of both the extracted bitumen and the residual mineral matter (breccia) after benzol extraction indicated that the bitumen had probably not been formed by the destructive distillation of bituminous coal. On the other hand, the bitumen closely resembles lignite-tar pitch in its considerable solubility in alcohol and in giving the diazobenzol reaction, indicating the presence of phenols. Further evidence as to its lignitic origin is furnished by the presence of cresols, the emulsification of the bitumen with hot concentrated sodium hydroxide solution, and by its acidity to phenolpthalein indicator.

The odour of the bitumen especially when heated strongly resembled that of Stockholm tar, a viscous, black, sticky liquid obtained by the destructive distillation of pine wood. It differed, however, from this substance and from coal tar in *not* being completely soluble in absolute alcohol, in being, on the other hand, completely soluble in cold carbon tetrachloride, and in not giving the Morawski colour reaction for resin acids. Possibly the parent lignite had been derived from conifers, the resin, however, having undergone sufficient chemical change to render it incapable of giving the above characteristic reaction.

It was interesting to note that the 81 per cent. of mineral residue remaining after extracting the 19 per cent. of cementing bitumen from the breccia lost 6 per cent. by weight on ignition to bright red heat in a platinum crucible, and that during the early stages of this distillation, and at a comparatively low temperature, a small quantity of pale brown, viscous oily fluid was obtained. The quantity was too small to permit of further investigation, but it was markedly greasy to the touch, like a viscous petroleum distillate.

Mr. Wolf had no hesitation in concluding that the bitumen had been derived from the destructive distillation of lignitic material.

A clue was given to the possible origin of the oil in this case by the peculiar yet characteristic odour of the impregnated rocks, but other cases can be instanced where oil-impregnated rocks betraying a normal petroliferous odour have been formed by the action of intrusives on carbonaceous beds. In one case when exploring for coal with a core drill in South Africa a core of oil-saturated oil sand was obtained. The sample revealed all the features of a true oil sand, yet a detailed examination of the area and a careful examination of all the facts forced the conclusion that the oil had

been derived from the distillation of carbonaceous material by intrusives which pierced the strata of the district.

Seepages of oil due to distillation of carbonaceous or kerogenous shales have been reported from both Scotland and elsewhere in South Africa.

Native Bitumens.—In a few parts of the world, veins of native bitumen are found, and in some cases mined. These native bitumens always occur as intrusions in fissures, and curiously the fissures are generally vertical. Sometimes they have a width of from 10 to 30 ft.—and it is a feature that they can generally be traced for long distances—miles in some cases—in a straight line on the surface. That the solid native bitumens have been derived from liquid products is proved by the frequent occlusion of particles of country rock. All appearances tend to indicate that the bitumens are metamorphosed heavy oils which have entered fissures during earth movements and solidified in situ.

Minor developments of bitumen veins have been recorded from many oilfield districts where usually in the form of Grahamite they fill fissures in disturbed clay near complex or disturbed structures. Numerous veins may be seen in the McKittrick field, California, in that part where the structure is particularly complex. Deposits are common in Trinidad, but only in the San Fernando district, far removed from a proved oilfield, do they reach economic importance. The Vistabella grahamite vein swelled out to a width of 30 ft. at one point.

Fragments and small lenticles of solid bitumen are, however, too common to warrant especial comment. They appear to form mainly in disturbed ground in oil country, and it is worth recording that particles are often ejected from mud volcanoes.

Special interest attaches to the larger veins of native bitumens which introduce far more perplexing problems.

From various parts of the world we have records of veins of considerable size and their usefulness as indicators of oil has been discussed from several standpoints. If we assume, as appears necessary, that the bitumens represent the residues of natural oils, they must have been derived from some source of importance, and unless downward migration from a former overlying stratum is accepted as likely they must connect with some oil-bearing stratum. In Barbados, Manjak veins may be followed through tortuous fissure systems in clays to an oil sand containing liquid oil, but such has not been the case with the large veins worked to considerable depths and for long distances.

Cuba has attracted a deal of attention from oilfield operators, especially American, and many test wells have been sunk in the search for oil of which manifestations are so numerous and striking.

Amongst the most impressive phenomena must be included the great Grahamite veins which at times reach a width of 30 ft. and have been worked to a depth of several hundred feet. The bitumen fills vertical fissures along strike faults showing considerable differential vertical movement, but oblique, though less important fissures also contain bitumen. Gas is frequently met with in the workings, but liquid oils do not appear to have been found.

In the vicinity of the Cuban asphalt veins occasional seepages of liquid oils have been observed, and drilling has disclosed the existence of both oil, gas and salt water. Only at one place east of Havana has payable oil been struck, and that was found in Serpentine. Oil of a specific gravity of 0·880 was produced over an area of only a few acres.

The Albert bitumen vein of New Brunswick has been worked to a depth of 1,300 ft. for a distance of 2,800 ft., thus representing the residue of a very considerable volume of fluid oil which must once have gained admission from some large and obscure source of supply. Although much prospecting and drilling have been carried out in the district and other indications of oil occur, only small yielding oil and gas wells have so far been struck.

Three famous veins of Gilsonite occur in the Uinta Valley of Utah. The maximum width of the chief vein is 18 ft., and for four miles out of the total length of eight miles the width varies between 8 and 12 ft. A famous West Virginia vein is one mile long, 1,500 ft. deep and 2 to 5 ft. in width.

Other important veins of bitumen occur along the Andean foothill country in the province of Mendoza and Neuquen. Drilling in the region of these veins has led to no useful results, although some heavy oil with gas and water has been struck at San Rafael in Mendoza. It would thus appear that although these intrusive veins of bitumen seem to prove the former existence of very considerable quantities of petroleum, they cannot be regarded as favourable indications of present-day supplies. It is unlikely that the present deposits represent more than a small part of the total fluid which exuded, and for such large volumes of oil to escape within a small compass suggests that local conditions were favourable for oil concentration prior to the fissuring and subsequent to conditions which have not been substantially modified since, as the unbroken condition of the veins testifies.

Ozokerite is another mineral occasionally found filling fissures in disturbed ground in oilfields regions. As it is a metamorphosed product of paraffin base oils, its occurrence may always be considered of interest to oil prospectors. Only in a few countries is it found in commercially useful quantities, but small stringers are quite common in oil measures where oils rich in paraffin wax

are found. The deposits of Boryslaw and Stanislaw, Galicia, are well known, and have been extensively worked, but from Rumania, Russia, and many other places less important occurrences of ozokerite have been recorded. The presence of ozokerite veins always denotes disturbed geological conditions.

Salts and Sulphur.—Neither salt nor sulphur can be regarded as proof of the presence of petroleum, but, on the other hand, saline and sulphurous waters are so commonly associated with oil measures that, given other contributory signs, their presence adds supplementary evidence when investigating an area. Both salt and sulphur in crystalline form are often present in oil measures. The former sometimes occurs in massive form, and constitutes the cores of anticlines and domes above or aside which important supplies of oil have been developed. Sulphur is nearly always associated with oils of a limestone origin, and limestones above or in proximity to the oil-bearing stratum are occasionally heavily charged with sulphur. Many of the limestone cap rocks of the Gulf Coast domes are richly impregnated with sulphur derived, it is believed, from interaction between anhydrite and the hydrocarbons from the surrounding sedimentary beds. So extensive and rich are the sulphur-bearing limestones (containing up to 70 per cent. sulphur) in some of the Gulf Coast salt domes, that single bores at Calcasieu, worked by the steam and air lift method, have yielded 400 to 500 tons of pure sulphur a day and have attained a total of 600,000 tons. The limestones of Jemsa, Egypt, were worked for sulphur long before the oilfield was developed.

Brine is almost universally associated with oil measures, possibly because oil can only have been preserved under conditions which prevented the free circulation of meteoric waters, and so led to the retention of the original waters of sedimentation in a nearly undiluted state.

Only in a few cases have fresh waters been recorded from productive oil measures, consequently if brine is found in association with gas, where geological conditions are favourable, an investigation is justified. Outcropping oil strata rarely fail to exhibit some indications of salt, and under peculiar conditions where salts are leached from outcropping beds by rain water and later evaporated by wind and heat, considerable deposits of salt may be formed. Sometimes the brine ejected from mud volcanoes will result in deposits of salt about and around the mounds.

Sulphur waters are particularly common in oilfield regions, and where oil measures outcrop or approach the surface under disturbed conditions oozings of sulphurous water may be very extensively developed. Most of the seepage sulphurous waters emit a strong

odour of hydrogen-sulphide, and they leave a trail of flocculent, objectionable-looking matter resembling sewage in appearance. Often the sulphur waters are warm and not infrequently reach a temperature of 120° to 140°. In such cases brilliant coloured algæ sometimes thrive in pools where the warm water collects, giving them a strikingly beautiful appearance.

No oilfield to the writer's knowledge has been proved in the neighbourhood of large springs of brine and sulphur water, but in many cases they are certainly associated with bituminous rocks, and in consequence cannot be disregarded except where geology precludes connection with oil measures, as when they issue from volcanic or metamorphic rocks. On the other hand, when drilling in oil measures where good yielding wells have been struck, heavy flows of both cold and warm sulphur and saline waters have been encountered. At the western end of the Grosny oilfield and in Cheleken, Russia, large flows of hot waters were encountered. As is well known the great Mexican Coastal fields are closely connected with warm saline and sulphurous waters which eventually replace the oil when the wells approach exhaustion.

The warm sulphur springs of Egypt, Palestine, Kaikent in the Caucasus, Salsamajori in Italy, and several in Trinidad are all more or less directly associated with oil-yielding strata, although in no case mentioned have nearby oilfields been located.

As a general rule the larger springs must be regarded as unfavourable to local development, whilst the smaller seepages nearly always occur where the strata are faulted or disturbed. A line of faulting or a zone of fracture can often be followed in oilfield regions by a string of sulphur water springs.

Conclusions.

Although an effort has been made in this paper to indicate the relative importance of different kinds of manifestations which direct the search for oilfields, it should be clearly understood that other factors than mere "shows" guide a decision. It is especially advisable to emphasise the importance of environment, for as already stated, much more pronounced manifestations of oil are to be expected from certain types and ages of strata than others. Although there are exceptions, as in the case of Mexico and Alberta, Canada, nearly all the highly spectacular oil shows are associated with sedimentaries of Tertiary age. This is due to the usual greater productivity of oil measures of Tertiary age than those of other ages. Taking the U.S.A. as an example—and a perfectly fair one as the country has produced about 65 per cent. of the World's production of oil to-date extracted from

beds of all geological ages—figures show that up to 1925 the yield per acre of worked oilfields had been approximately as follows :—

Oilfields of Palæozoic age	.. .. ..	1,200 barrels per acre.	
„ Mesozoic „	.. .. ..	4,600	„ „
„ Tertiary „	.. .. ..	30,000	„ „

Oil measures of Tertiary age are generally characterised by a much larger number of separate oil-bearing sands and a much greater thickness than those occurring in older rocks; consequently, the discovery of a single outcropping sand in strata of Tertiary age has generally a greater significance than a similar find in older beds. In many Palæozoic and Mesozoic oil measures, oil is restricted to one or several well-known sands or limestones separated by great thicknesses of barren beds, whilst in the majority of Tertiary measures oil may be found in almost any sandy lenticle in a succession that may reach thousands of feet in thickness.

When generalising in this way, the great limestone fields are intentionally ruled out, as under the exceptional conditions of Mexico and Persia it would matter little to what age the containing limestone formation belonged. In neither Mexico nor Persia was the presence of the great reservoirs of oil originally suspected, as in outcrops the reservoir rock did not give evidence of oil saturation.

Some geologists attach great importance to the presence of a "Mother" rock when considering the oil prospects of an area. What features characterise a "Mother" rock cannot be very clearly defined. Ralph Arnold based much of his work on the belief that oil in California was derived from diatomaceous and foraminiferal shales, and Mrazec in Rumania worked on the basis that oil was derived from the Miocene Salifère far away from which oil is never found. In many countries the oilfields are closely related to some particular series of beds, generally a clay or shale group, although in outcrop these associated beds do not always reveal evidences of free oil. Frequently the oil measures are obviously only containers of a migrated product from beds of another age, as an investigation in the district will demonstrate.

American geologists working in the Eastern and Mid-Continental areas where oilfields are located in Mesozoic and Palæozoic strata seem to regard dark clays or shales as the most likely "Mother" rocks, betraying as they often do, evident signs of past organic matter. As there is little unanimity concerning the origin of oil in most oilfields the determination of the "Mother" rock cannot be regarded, in most cases, as essential knowledge in judging the prospects of a region.

A much more important point needing consideration is the extent to which a departure from the conventional could be accepted for structures in the locality where the manifestations are found. As is well-known, concentration of oil on a commercial scale is possible under widely divergent geological conditions, rarely conforming with text-book ideas, but in some regions no commercial oil is found unless local structures conform closely to the recognised form. Thus in many of the Mid-Continental areas of U.S.A. few geologists would advise drilling on a structure when there was not "closure," a term not commonly used by geologists outside America, and practically unused by those working in oilfields of Tertiary age owing to the absence of key horizons, the prevalence of excessive faulting, and the comparative rarity of complete domes.

The necessity for closed structures seems to exist in those regions where oil-forming conditions were confined to narrow vertical limits; consequently, commercially valuable pools of oil could only be formed by a very complete displacement of oil from the surrounding beds as well as a nearly entire preservation of both oil and gas under, perhaps, hydrostatic conditions.

Divergent views are held concerning the horizontal distance oil will migrate before concentration and retention in flexures. Many geologists are disinclined to accept the view of long distance migration. Certainly the quantity of oil abstracted from many pools does not necessitate the assumption of distant travel unless one considers the "Mother" rock to be either very thin, very lean in oil content or the contents to be very imperfectly transferred. American geologists often give consideration to the width of undisturbed synclines between anticlinal flexures. The extent of unbroken flanks to folds must naturally be considered when successive anticlines lie parallel to each other.

A line of research which has received considerable attention in recent years and provided some illuminating if not generally applicable results has for its object a correlation between the metamorphosis of rocks and the character of their oil contents. David White first directed attention to the relationship between the carbon-hydrogen contents of coal and the nature of hydrocarbons in a geological succession. He demonstrated that in the Pennsylvanian Oilfields heavy oils of 0·835 to 0·875 sp. gr. were met with when the ratio of fixed C to H in coals was 50 to 55 per cent.: that oils of 0·802 to 0·825 sp. gr. were found when the ratio was between 55 to 60 per cent.: that much gas and light oil appeared in the zone of 60 to 65 ratio, and that only bituminous residues and traces of oil and gas occurred when the ratio of C to H reached 70 to 80 per cent. Although this theory

has been found to agree with observations in certain American Palæozoic rocks, there is, the writer believes, a disinclination on the part of British geologists to concede that the differences in coals are always the consequences of metamorphism due to pressure and temperature. The different grades of coal are thought to be due to depositional factors in many cases. This line of study has led other investigators into efforts to establish a relationship between the "lithification" of shales and the nature of the hydrocarbon contents of rocks, based on the same process of reasoning, but applicable where coals are non-existent. J. H. Wilson has given the following comparisons:—

Stage of metamorphism.	Sp. Gr.	Equivalent fixed C contents of coal.
Silt—deposit	Up to 1·25 ..	Below 50 per cent.
Consolidated mud	1·25 to 1·80 ..	„ „
„ dry clay	1·65 to 2·25 ..	„ „
Fissibility developed	2·0 to 2·40 ..	50 to 60 per cent.
Lithification „	2·25 to 2·65 ..	Above 60 per cent.
Metamorphosed to Cherts ..	2·50 to 2·90 ..	„ 95 „

Another line of study is being conducted on the colloidal contents of clays with a view to determining peculiarities which characterise the clays and shales associated with oil measures.

Finally, some useful information can sometimes be deduced from analysis of waters associated with oil measures. As is well-known, saline waters which have come in contact with beds containing hydrocarbons often disclose an unusually small percentage, or entire absence, of sulphates, where ordinarily they would be anticipated. The information furnished by analysis might at times prove valuable in supporting other data.

DISCUSSION.

Mr. T. Dewhurst, in opening the discussion, said he was sure that all members present would agree that they were indebted to the author for having brought before them this very important subject, as it was undoubtedly a very difficult matter to adduce the real significance of surface indications of oil. As the author had stated, a number of oilfields had been discovered as a direct result of drilling on surface indications; in fact, one might go further and point out that certain oilfields were discovered and worked by natives long before the modern petroleum industry arose. For example, in 1797 there were over 500 shallow wells producing oil in the Yenangyaung Oilfield, where the natives had drilled on the strength of surface indications. Similarly, in other countries such as Galicia, Rumania, Persia, etc., oil was obtained from pits and/or shallow wells before machine bores were introduced. It should therefore be borne in mind that

not only had oilfields been discovered in the past by drilling on surface indications. but that they had been discovered by people who knew nothing whatever about the subject of oil prospecting. It was possible that that fact had led to gross exaggeration of the importance of seepages and the significance of surface indications as a direct guide to the discovery of commercial pools or stores of oil. But there was another side to the picture. He was confident that in every important oil-producing country cases had occurred in which wells had been drilled on oil seepages, or where surface indications existed, and had ended in failure; in fact, he dared to aver that if the history of this subject were written the complete story would be little less than appalling. Experience of that kind had led to under-estimation of the significance and value of seepages; and it was because of these opposed aspects of the question that it was somewhat difficult to arrive at a true understanding of the significance of surface oil indications. Possibly the best way to approach the subject was to consider, in the first place, that the surface indications of oil existed because the oil was escaping, whereas when one was searching for a commercial store of oil one did not look for a place where the oil was escaping, but for a place where the oil had been prevented from escaping and had been retained in the strata. It was only in those particular cases where seepage of oil and also retention of oil occurred together that surface indications had any significance as direct indications of the presence of commercial pools. There were two well-known cases of that kind. In the first place, oil might be retained in outcropping beds owing to the sands being sealed by the products of inspissation. Striking instances of that kind were afforded by the Digboi and the Mene Grande Oilfields. The second case occurred where there was a thick oil series, only a portion of which had been weathered away or denuded at the summit of a dome or anticline, so that the oil seeped away at the surface in the upper part of the oil measures, while the lower part was concealed below the surface. The oil was trapped in the lower beds, and if a well were drilled these hidden stores of oil were discovered, their presence having been directly indicated by the seepages in the outcropping beds in the upper part of the series. It was necessary, however, to be very careful in these cases as he recently came across a case in which a very rich oil series existed near the surface; in fact, in one place it had been cut into by a very deep nullah, and there was a big seepage at that point. In fact, so much gas and light oil had escaped that only a little dead oil was left underground. That was a case of a big oil store having been ruined by a single seepage. It was important therefore to know that at least a portion of the oil series was still intact if it was decided to drill

on surface indications. He also came across another case which illustrated a danger which it was necessary to try and avoid. In that case a thin oil series was exposed which gave seepages far down the pitch of the general structure, and wells there had not been successful. It was possible that oil occurred elsewhere, but in a lower and separate oil series. In this case, therefore, the seepages did not point the way to oil even though this may exist in the neighbourhood. It was therefore necessary to be very careful when drilling on seepages or in trying to assess the value of surface indications, that is, if an attempt was being made to find oil directly from such indications. It was, of course, necessary not to study surface indications alone, but to consider them in relation to the stratigraphy and the general geological structure of a region. By this means it was possible to form sonnd views regarding the migration of oil over a large area, and this should indicate points where the oil might have accumulated in large quantities, although there might be no surface indications at these important points. As stated, however, such concealed stores of oil could not be discovered by studying surface indications alone and attempting to find pools directly from them; it could only be done by recognising that surface indications are only part of the evidence, which must be studied in conjunction with all the stratigraphical and structural evidence obtainable before attempting to adduce conclusions and to make recommendations. It was therefore not at all an easy matter to estimate the significance of surface indications and he thought the members were much obliged to the author for having brought forward for discussion a paper dealing with the subject.

Mr. F. G. Rappoport thought that one of the most interesting cases in which investigators were misled by oil seepages occurred in the Maikop oilfield, where a very large number of most excellent exposures occurred all over the field. On drilling, however, in many parts of the field these particular oil sands proved to be failures, either the sands being waterlogged or giving very little oil. It was a curious fact, however, that on drilling deeper a light oil lenticle was discovered which had never got to the surface at all. This rather bore upon the remarks Mr. Dewhurst had made. It was, in fact, this light oil which gave life to the Maikop field, and if it had not been discovered in that way probably the Maikop oilfield would never have existed at all. It raised the hope that along that same line similar lenses of light oil would be discovered in the Maikop field in the future. The point he wished to impress upon the notice of the members, however, was that those outcrops actually proved most misleading so far as that particular oil sand was concerned. Another point which had interested him

was the author's statement regarding limestone, with an odour of petroleum. He could support that statement from personal knowledge, because in a district of Peru which he visited there were numerous oil seepages in the river and up on the banks a very thick black limestone which, on being broken, had a distinct odour of petroleum.

Mr. J. Romanes said that there was one point not mentioned in the paper on which he would like to hear the author or others express an opinion, *namely*, the possibility or probability of Pleistocene or recent formation of petroleum giving rise to surface indications which naturally, would be absolutely valueless as indications of oil at depth. In this connection he described a case he investigated two years ago in Dutch Guiana. A creek some 50 kilometres from the sea, which though tidal was entirely fresh water, was reported to have seepages of light oil in it. A search at length disclosed one spot at which the recent creek mud not only smelt strongly of petroleum but yielded a distinct film of very light oil when squeezed out under water. Pits dug around this place proved that the petroliferous mud was underlain by an older creek mud very much more consolidated but still containing well preserved leaves, twigs, etc. This older mud showed no trace whatever of petroleum or petroleum gas. From the geology of the district he believed that these recent deposits were only some 40 to 50 metres thick and overlay a mineralised Palæozoic series which, when exposed, were just about as unpromising a formation for oil to occur in as could be imagined. In that case he was driven to the conclusion that the very light petroleum was of recent origin and actually formed in the creek mud, the only difficulty he saw was the fact that the conditions were entirely fresh water. He asked if the author had met with similar occurrences, since, if oil could be so formed, such indications might be very misleading.

Another case occurred in British Guiana where, along certain parts of the coast, mysterious intermittent exudations of heavy asphalt had been observed. The underlying formation consisted of very thick recent deposits and he believed that he was right in saying that the late Sir John Harrison considered the asphalt to be of recent origin and formed in the alluvium.

The author had referred to Cuba and the widespread oil indications there. The speaker had carried out a certain amount of geological work there and seen some of these indications and would like to put forward a theory with regard to them. More than a hundred wells had been drilled in Cuba, practically all of which had had some show of oil, but no commercially successful field had been discovered. In one field referred to by the author

a certain production was obtained, but it failed to develop into a commercial success. It appeared to him that in Cuba one had the result of the more or less gentle thermal metamorphism of a petroliferous series. He was not aware that such a case had actually been described, but obviously the probability was that here and there large igneous intrusions must have occurred sufficiently close to petroliferous formations to affect them. In Cuba one had a whole range of petroleum products. On the one hand are the asphalt deposits which cut through the other formations exactly like igneous dykes and which give the impression of having been considerably heated before intrusion. On the other hand, at Motembo, in the province of Santa Clara, wells gave absolutely water-white petrol which had been used in an aeroplane just as it came from the well.

It seemed to him that such thermal metamorphism might account for some of the regions where in spite of very prevalent indications, drilling had failed to give commercial production.

He would like to know whether others held the same views with regard to the possibility of the thermal metamorphism of petroliferous beds giving rise to these phenomena.

Prof. V. C. Illing, said that, as Mr. Dewhurst had stated, the really important point was the question of the significance to be attached to an oil indication. The speaker thought that, to a large extent, many people failed to realise that bitumen was a very prevalent substance in the earth's crust. It was exceedingly common if it were only looked for, and searching analysis would find it in most of our argillaceous sediments, and often even in sands and limestones. There were a good many spurious oil indications, and there were innumerable examples of bitumen, which meant nothing more than the fact that it was an exceedingly widespread substance in the earth's crust. What the members were interested in was the forthcoming commercial supplies of oil, and in that case the significance of an oil show was often like the old analogy of the horse and the stable. Very often the bitumen had been there and had gone; sometimes it was going, and occasionally it had not yet gone. Everything really depended on the question of the geological significance of an oil show, and that was often a most difficult problem that had to be faced. Unless an oil show was interpreted from the point of view of structure and geological history, any value attached thereto should be severely discounted, the mere occurrence of an oil seepage was only one link in the chain of evidence.

The speaker joined issue with the author's remarks on the Pitch Lake of Trinidad. Personally he did not like to call the Pitch Lake an oil show, although it was usually described as one

of the biggest oil shows in the world. The great difficulty in interpreting the Pitch Lake was to account for the basin in which the pitch existed. The author assumed the pitch flowed superficially into and filled the basin, thereby begging the question. The speaker was quite convinced it was not a surface flow at all, but that it was an underground pitch deposit of which the roof had fallen in, thereby leaving the centre exposed while the marginal pitch extended underground.

He did not know whether he was a purist in such matters, but he did object to the term metamorphism being applied to the production of a ozokerite, as stated by the author. Metamorphism was a well-recognised geological term, covering many processes of physical and chemical change, but the use of it in the instance referred to was unfortunate.

An interesting point about brine in deep oil-field waters was how a concentration thirteen or fourteen times that of sea-water was obtained, and why these brines were relatively free from sulphates. He wished the author had laid greater stress on the difference between Palæozoic fields and Tertiary fields. He did not quite agree with the author's explanation in that respect. It might be that the Tertiary oil sands, as a whole, were more prolific, but it must be borne in mind that some of the pools in the Palæozoic fields were extraordinarily rich. Did not the author think it was more likely that the whole question was one of disturbed tectonics and denudation? It was well-known that oil seepages at the surface were much more likely to occur with strong faulting and fracturing. These were much more prevalent in the known Tertiary oilfields, and it seemed to him that it was more a question of tectonics and denudation than a question of the prolific nature of the oil sands themselves. The depth of cover in the case of the main Palæozoic fields is generally high, the disturbance slight, and in most cases oil shows are rare or absent.

He was particularly interested in the cases to which Mr. Romanes had called attention, because it seemed to him quite likely that in fresh-water (as well as salt-water) formations under such conditions petroleum might be produced by bacteriological decomposition. He did not think, on the whole, he would be prepared to take the British Guiana example as conclusive. His own observation had led him to doubt the indigenous origin of the British Guiana oil shows on the coastal belt. Indigenous origin is often difficult to prove or disprove, but if we were to make sure of our progress in knowledge, the onus in each case should always be placed on the proof.

Dr. A. Wade said he found himself more or less in agreement with the remarks made by the author and the various speakers.

Arguments on both sides for almost all the points raised could be adduced. He was particularly interested in the point raised by Mr. Romanes with regard to the occurrencies of petroleum in recent and Pleistocene formations. There could be no question that almost every kind of sedimentary deposit that was being laid down at the present day contained a small amount of extractable oil. He knew that to his sorrow, because, in carrying out his work for the Australian Government, samples were sent to him from almost every part of Australia, each certified by the Government analyst of the different States, and all guaranteed to contain oil. The Government analyst said they contained oil, and therefore they must do so. That puzzled him very greatly for a long time. He then started to carry out some investigations and ascertained that, undoubtedly, they did contain some oil. Incidentally that rather vitiated the taking round of petrol or chloroform, or other solvents, for the purpose of finding whether a sand contained oil or not, because if a little oil could be extracted from any rock, he was afraid it was no use taking round petrol, chloroform or other solvents. In some cases the amount of oil found was very remarkable, particularly from seashore sands, and even freshwater deposits. With regard to freshwater deposits, the Queensland deposits in the Great Basin were certainly of freshwater origin, and there is no question either, in his mind, that the petroleum which was obtained in the deep bores originated in those deposits. It seemed to him, therefore, that petroleum could be formed in freshwater deposits just as well as in salt-water deposits, although perhaps not to such a great extent. In his report on the Queensland area he dealt with the question of thermal metamorphism. Undoubtedly thermal conditions had caused dissociation in the bituminous contents of the strata. Mud volcanoes existed in Central Queensland, where they were called mound springs, but they behaved very much like the ordinary mud volcano. A more peculiar feature still was that sand volcanoes existed, or mounds of sand, which were constantly bubbling up out of the ground and growing. Those cases, however, were only apparently related to the mud volcano, which was dependent on gas and oil, but they certainly did misguide amateur prospectors. He was afraid the amateur prospector would be very much misguided by the author's paper, in which he would be able to read a lot of things, then go round and find ozokerite and think he had discovered an oilfield. It must be remembered that ozokerite was not necessarily ozokerite to some of the amateur prospectors with whom he had had to deal; in fact, mutton suet could take its place. He had had pieces of paraffin-wax with the stamp of the refinery on them brought to him as samples of ozokerite, and he knew of

cases in which quite large sums of money had been raised for oil propositions simply on evidence which was no more reliable than this.

Mr. H. B. Milner said he desired to call the author's attention to what he thought was rather an important omission in connexion with the Texas and Louisiana oilfields, namely, that no mention was made of the perplexing subject of paraffin dirt. He noted the author stated in the course of the paper that no less than 20,000,000 dollars had been spent on 675 unsuccessful test wells in search for salt domes in the Gulf Coast region of the United States. He thought it would be found that quite a large proportion of that money had been spent in testing paraffin dirt outcrops. He had had some experience of that substance in the field, and with his colleague, Mr. Wolf, at the Royal School of Mines, came to the conclusion, after fairly exhaustive examination, that paraffin dirt was absolutely no direct indication of petroleum as such, a conclusion which had been accepted by some of the leading geologists of the Gulf Coast fields. Paraffin dirt was an extraordinary substance, and he thought that under the circumstances, and in view of the fact that some recent literature had been devoted to it, the author might be induced to add a few words to his paper on the subject.

Mr. Charles Dabell said he had listened with much interest to the cursing to which surface indications had been subjected. Mr. Dewhurst had given cases in which, although a surface indication might exist, yet it was not a clue to the lighter oil horizon which apparently was not outcropping. He would like to know, however, whether in the author's opinion any field had been successfully developed where surface indications had not been the first clue. He was not sure whether that was not the case in the huge Grosny oilfield of South Russia, as he had never seen any surface indication of oil there. The author suggested in his paper that development work did not take place where there were no indications, but the Grosny oilfield was a field in which, as far as he knew, great development had taken place without any surface indications being present. In the paper the author stated "No oilfield to the writer's knowledge has been proved in the neighbourhood of large springs of brine and sulphur water." He believed that in the Persian field near to the Maidan, satisfactory wells had been brought in, in spite of the fact that on that field there were large sulphur springs. He hoped Mr. Dewhurst would correct him if he was wrong in that statement.

The Chairman, in concluding the discussion, said he hoped the members would forgive him if he ventured to make one

remark, as he was a mere tyro on the subject of the paper, but Prof. Illing's contention that the formation of pitch in the pitch lake was subterranean rather than surface brought to his mind an experience he had when he was asked to inspect a well some considerable distance from the Trinidad Pitch Lake. The valve was opened and from the well emerged a worm of pitch which curled and heaped up on the derrick floor. The worm or plug must have been some 50 to 60 feet long. Gas then blew, and ribbons of pitch went right up to the top of the derrick—a remarkable spectacle. The well was, if he remembered rightly, about 900 feet deep. These facts seemed to support the contention advanced by Prof. Illing.

Mr. A. Beeby Thompson in reply said, with regard to Mr. Dewhurst's case of a symmetric anticline with an oil sand outcropping on scarps on the two flanks, one would naturally assume, if in an oilfield district, that the sand outcrop gave a clue to what might exist deeper, but it was essentially a case where a decision would be guided by the age and characteristics of the beds on which the geologist was working. If a Palæozoic area was being dealt with one might hesitate to advise drilling. On the other hand if the beds under consideration were of Tertiary age the geologist might reasonably infer that the outcropping sand represented the upper of perhaps a dozen sands which lay deeper and which would be sealed. It was always necessary in such cases to connect the environment with observed facts.

He was very glad Mr. Rappoport had called attention to Maikop because it represented a typical field example. In that case the seepages although arising from beds which had never given commercial supplies of oil, did indicate the existence of oil, as on drilling deeper oil sands were tapped which gave a high grade oil.

Mr. Romanes had raised several important points, especially the question of thermal influences at depth. It was, perhaps, difficult to distinguish filtration and distillation effects, yet the former must be kept carefully in view where light oils occurred. He was largely in agreement with what Professor Illing had said about the pitch lake of Trinidad (except the laccolite idea). He never regarded it as a simple seepage. He always thought it originated from one or more oil sands which did not outcrop at the surface. He had always assumed that the basin was formed by a sort of mud volcano action which gradually deepened the basin, whilst the overflow was carrying away considerable quantities of material. Until drilling was undertaken round the lake he held in view that the pitch represented the inspissated residue of normal density oils. On drilling, only heavy oils were obtained

and a modified interpretation had to be placed on its origin. Identical features were disclosed by drilling near the deposits in Venezuela, as real pitch and not true oil was struck. The possible connection of sulphur with these heavy-oil residues raises an interesting question.

He was pleased that Professor Illing had referred to the subject of relationship of lithology and metamorphism to oil contents of strata. He had felt most strongly that one's advice on the value of an area must be guided by the geological age of the structures that existed. In Tertiary country one could often quite confidently advise drilling on very much less perfect structures than where older rocks occurred. It might be, as suggested, that the more highly consolidated beds facilitated the escape of oil through fissures and joint creeks, but he thought that there were other explanations. He was inclined to consider that the actual material which had produced the oil was limited in quantity, and that it was, consequently, necessary to have very perfect concentration to produce an oilfield under these conditions.

He had followed Dr. Wade's remarks with interest, and recalled his references to the carbon-hydrogen ratio deductions in some of his papers on Australian oil prospects. With reference to the use of solvents for testing oil rocks, he might say that they were only used for tests on certain rocks having the appearance of oil sands. Sometimes it was difficult, as in some parts of Egypt, to distinguish between an oil and an iron-stained sand.

In reply to Mr. Milner, he said he had purposely refrained from mentioning oil dirt as an indication, in consequence of having read Mr. Milner's article on the subject. Mr. Milner had probably seen comments on his deductions in the American Press, where his conclusions were questioned. He was sure members would like to hear what Mr. Milner had to say in reply to these criticisms.

Mr. Dabell had referred to the Grosny Oilfield. As a matter of fact there were indications of oil at Grosny, near which Mr. Alfred Suart sunk his first well. The well was actually located on the crest of the anticline where the fold reached its maximum elevation, and the area around, known later as the Ackverdoff property, proved to be the richest in the field. The well got out of control when oil was struck, and the flood of oil caused so much damage to property in the valley below that Mr. Suart was forced to dispose of the property for a nominal price in order to pay the claims for compensation that were made.

On the motion of the Chairman, a hearty vote of thanks was accorded to Mr. Beeby Thompson for his interesting paper, and the meeting terminated.

The following written contribution to the discussion was subsequently received from **Mr. I. A. Stigand** :—

The author is to be congratulated on having been able to produce a very interesting paper around a difficult title, for the significance of oil-indications is a very uncertain quantity and so different in different cases. Sometimes the strongest indications have marked the best and most productive parts of fields (as, *e.g.*, in Baku), while in many cases copious seepages only serve to indicate a sign that the area is unfavourable (as, *e.g.*, among many instances, in Kertch, Taman and N.W. Borneo). This is, of course, dependent on their relationship to the structural conditions of the formations where they are found.

I should like to ask the author whether he knows of any cases of mud-volcanoes (of the petroliferous or natural gas type) found occurring in formations of pre-Tertiary age.

Although mud-volcanoes generally denote unfavourable conditions, cases of oilfields not unassociated with them are to be found, of which, I suppose, Trinidad affords the most noted example (although I am not aware of any instances where they actually occur within any productive field). I remember finding a small mud-volcano on the anticline of the southern extension of the Grozny Field—on the south side of the Terek River. At that time, however, no work had been done in that region, but a considerable field has since come into existence on this anticline, although I do not know whether the field has yet extended as far as the locality of this mud-volcano.

As regards mud-volcanoes in Taman and Kertch, I do not think that there can be said to be a general absence of sands or porous beds in this region (as is mentioned as having been suggested in regard to that end of the Caucasus). The Miocene clays are here thick and difficult to penetrate on account of the structural conditions and having been compressed into steep anticlinal folds. Below are to be found the sandstones of basal Miocene and Oligocene age, fragments of which are frequently ejected by the mud-volcanoes.

Mud-volcanoes appear invariably to be connected with great subterranean pressure, or compression, which is one of the factors. Although hydrostatic pressure is generally also largely present, there is usually to be found, associated with them, considerable compression deep down below the surface. In borings made in some of the uplifted anticlines of Kertch, the clay was forced up and ejected from the holes, and the casing crushed or crumpled, while somewhat similar phenomena have sometimes been experienced in Trinidad and elsewhere. Is it that the compressive movements, which have produced the steep anticlinal folding, are

still in operation? In Kertch and Taman there is evidence that these movements were prolonged at least after the Pliocene age—which accounts for the peculiar structure of steep uplifted anticlines separated by wide and flat synclines.

They are, as it were, natural wells or outlets produced by the pressure, having found an outlet along the line of least resistance—generally at faults.

The description of the occurrences found in Bulgaria is interesting, as an instance of the many cases of petroliferous indications produced by igneous or volcanic intrusions and action, although why such indications of petroleum or bitumen are not always to be found when suitable sedimentary strata have been intersected by volcanic intrusions, or associated with volcanic activity, remains to be explained.

In further reply to the discussion, **Mr. A. Beeby Thompson** wrote that both Mr. Dewhurst and Professor Illing had emphasized the view which he thought he had rather stressed in the paper—namely, that the significance of oil indications had to be judged in conjunction with tectonics, lithology and stratigraphy. Obviously oil seepages were evidence of loss of oil rather than of its present concentration, but the fact that oil and gas losses had continued for untold ages without exhausting known oilfields proved either that concentration proceeded at as rapid a rate as its loss or that the resistance imposed sufficient obstruction to prevent serious loss from beds lying beyond some ill-defined depth below the surface.

Professor Illing's suggested explanation of the pitch lake appeared to him to create as many difficulties as it removed. It necessitated a great laccolite shaped mass of pitch, of which there was no direct evidence on the underground marginal part. Where did the pitch originate, and what were the forces which gave rise to the laccolite, and why should the roof fall in if it were resting on solid pitch? If, on the other hand, the pitch lake is, as generally assumed, a seepage or series of seepages on a vast scale, the surface deposits would tend to be raised by the exuding pitch and removed by normal denudation, in addition to this much admixed sand, etc., has doubtless been removed by the overflow of pitch to the sea. These two processes would combine to form gradually a basin entirely filled with emulsified pitch.

The criticism of Professor Illing to the use of the word metamorphism as applied to Ozokerite is perfectly justified. The word has been used several times in the paper solely because no other appropriate word suggested itself, and other writers he thought

had found the same difficulty, and had expanded its customary meaning to types of alteration other than those correctly described as metamorphism.

Referring to the comments on the relative productivity of Tertiary and Palæozoic oilfields, the writer always considered that the large volume of gas per barrel of oil and the greater prevalence of gas sands in Palæozoic oil measures indicated an exceptional freedom from losses and consequently an absence of avenues of escape. Also, great thicknesses of quite barren strata may separate two horizons equally productive. All statistical data supports the view that Palæozoic oilfields are not nearly so rich as Tertiary of the unconsolidated type. The richest Palæozoic oilfields of America have only yielded about 10,000 barrels per acre compared with customary yields of 20,000 to 200,000 barrels per acre for oilfields of Tertiary age, with exceptional yields, as in Russia, up to 500,000 barrels per acre.

Both Mr. Romanes and Professor Illing have referred to the occurrence of oil in British Guiana under conditions which called for an unusual explanation. There is really no reason why the process of oil formation should not be in course of operation in such deltaic sediments. Sir John Harrison was able to present very convincing arguments against the transport of oil by sea currents to the site where it was found, but since drilling for water in these coastal sediments during the last few years, not only has a definite horizon with a petroliferous smell and containing beads of asphalt been traced in a number of bores, but in a recent well there was a strong blow out of gas. These facts appear to disprove the adventitious origin of those authentic oil shows which has perplexed many observers.

Mr. Stigand's contributed remarks are based upon some exceptional knowledge of misleading seepages. The writer is unaware of any true mud volcano in fields other than those of Tertiary age, although small sand and gas cones are sometimes associated with older oil measures. In one case in Trinidad the writer experienced the same difficulties as those described by Mr. Stigand when drilling into what proved a mud volcano. Drilling was forcibly stopped by constantly ejected clay.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

THE NINETY-SIXTH GENERAL MEETING of the Institution of Petroleum Technologists was held at the House of the Royal Society of Arts, John Street, Adelphi, London, on Tuesday, November 9th, 1926. In the absence of the President the chair was taken by SIR FREDERICK W. BLACK, K.C.B., B.A. (Lond.), Past-President.

The Secretary read the names of members elected since the previous meeting:—

Associate Members.—Douglas Gordon Smith, Colin Everett Spearing.

Transferred to Associate Member.—Geoffrey Squire Ffoulkes-Jones, Charles Wilfrid Fulcher, Harvey Satchell Garlick.

Students.—Jack Eliot Duckham, John William Weitz.

Members were reminded that nominations for Members of Council should be in the hands of the Secretary not later than January 31st next.

A paper on "Oil Fuel and Other Fuels from Carbonization Processes" was then read by Dr. F. Mollwo Perkin, C.B.E., Ph.D., F.I.C., F.C.S.

Determination of Benzene in Alcohol Solution.

By W. R. Ormandy and E. C. Craven (Members).

Since the method of Young for the dehydration of alcohol is likely to be employed on the large scale, it seemed desirable to seek a rapid and accurate method for the determination of benzene in alcohol. The straightforward method of dilution with water and measurement of the separated benzene is unsatisfactory on account of the solubility of benzene in weak alcohol. In a published note[1] it has been shown that the last 1 per cent. of benzene in the alcohol cannot be separated by dilution.

Experiments were made in which the addition of petrol spirit or heavier hydrocarbons was made before dilution. The separated top layer proved in most cases to be distinctly in defect of the volume added, even if salt solution were used as a diluent. This appears to arise from the emulsification of the hydrocarbons in the weak alcohol. Complete separation does not occur in any reasonable time.

It appeared probable, however, that the composition of the separated upper layer would be identical with that of the hydrocarbons left in suspension. Hence an extraction with a known volume of non-benzenoid hydrocarbons followed by a benzene determination should give the total amount of benzene present. As a basis for a quick method for the estimation o benzene in the upper layer, the high refractive index of benzene commended itself. It may be as well to anticipate here and state that the hopes entertained of this idea were not entirely realised, the benzene extraction being found in all cases to be far from complete. By working under roughly standard conditions, however, an empirical method has been devised on the lines of the above idea.

The refractometer used in these investigations consists of the familiar arrangement of two equilateral prisms[2] ($\mu = 1{\cdot}62$) mounted in a jacket through which water is kept running. The direction of the edge of the emergent beam is measured by a horizontal

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[1] Ormandy and Craven, *Jour. Inst. Petr. Techn.*, 1922, **8**, 31, 213-217.

[2] See, for example, Houstoun, p. 110.

telescope and graduated arc reading to 1′, giving an accuracy of about ·0001 in refractive index. Only a couple of drops of liquid are required, and the vertical prism arrangement is superior to the Abbe arrangement when volatile liquids are being tested.

With regard to the choice of an extracting liquid, it appeared to be important that this should not change in refractive index on partial evaporation. There appeared thus to be two possibilities :—

1. To use a heavy petroleum fraction so that evaporation should be negligible.
2. To use a light hydrocarbon, either pure or of narrow distilling range.

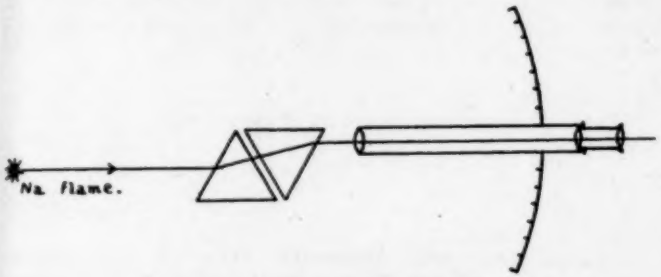


DIAGRAM OF REFRACTOMETER ARRANGEMENT.

The second alternative appeared to be the better from several points of view. The lighter the hydrocarbon the more does its refractive index fall below that of benzene, and for the same boiling point a straight chain paraffin would be better in this respect than a cyclic body. Since evaporation of benzene to some extent is unavoidable, by using an extracting liquid of about the same volatility as benzene it is ensured that evaporation will occur approximately *pro rata* and leave the benzene content of the separated layer unchanged.

The extracting liquids actually tried were :—

			Diff.
1.	White spirit, n_D 20° C.	1·4347	0·0667
2.	Heptane, n_D 20° C.	1·3877	0·1137
3.	Light petrol (93–105° C.), n_D 20° C. ..	1·4063	0·0851

The white spirit and the petrol were shaken out with 98 per cent. H_2SO_4 to remove aromatics.

The refractive index of benzene at 20° C. for the D line is 1·5014, giving the difference shown in the second column. Obviously a large difference favours the sensitivity of the test.

In the first experimental work methylated spirit was used. This, of course, necessitated blank experiments, and even later with commercial pure alcohol blanks were found to be necessary.

Into 50 c.c. of the spirit or solution of benzene in spirit in a 300 c.c. separating funnel is pipetted 5 c.c. of the extracting liquid. After mixing, 150 c.c. of 20 per cent. common salt solution is added, and the funnel gently shaken for a few moments. After standing five minutes the bottom layer is tapped off and the hydrocarbons washed with a further 25 c.c. of salt solution. The hydrocarbons are run into a narrow test tube and the refractive index taken. Since in all cases the difference of the refractive index from the blank is all that is required, it is convenient to express this in minutes of arc, the difference up to 2° or so being approximately proportional to the difference of refractive index.

Experiments with White Spirit.

1.

	Deflection.		Benzene.
1% benzene taken	24′	=	0·50%
2% „ „	49′	=	1·03%

Assuming the volume composition—refractive index relation of the mixture to be a straight line, the above deflections correspond to the amounts of benzene shown on the right.

2. As in (1), but 25 c.c. of sample used instead of 50 c.c. :—

	Deflection.		Benzene.
1% benzene taken	15′	=	0·62
2% „ „	30′	=	1·25

3. The white spirit was now dropped and heptane was used as an extracting liquid :—

Benzene taken.	Deflection.		Benzene.
1%	41′	=	0·60%
2%	86′	=	1·26%

4. As (3), but using tap water instead of salt solution :—

Benzene taken.	Deflection.
2% ..	74′

5. As (3), but using saturated salt solution :—

Benzene taken.	Deflection.
2% ..	86′

It was thought that the extra sensitivity gained by using salt solution was not outweighed by the convenience of using tap water. In all succeeding experiments, therefore, tap water was used. In place of methylated spirit commercial pure absolute alcohol was now used. If this had been really pure, the blank test should have been the same as of the original heptane. This was found not to be the case :—

6. & 7.

	Refractometer reading.
Original heptane	18° 20′
Do. after shaking with water	18° 20′
Commercial absolute alcohol No. 1	18° 16′
Do. after "topping" about 5%	18° 16′
Commercial absolute alcohol No. 2	18° 18′

It would appear that both these samples contain impurities in amounts of the order of 0·1 per cent. which raise the refractive index of heptane.

Since it appeared from the previous work that the extraction of benzene is in all cases incomplete, it was decided to regard the method as empirical and by making up a range of benzene alcohol solutions to prepare a calibration curve of benzene content against deflection :—

8.

Benzene taken. Per cent.		Deflection.
0·25	..	10½′
0·50	..	20′
1·00	..	41½′
1·50	..	60½′
2·00	..	81′

The half-minutes arise from the fact the mean of two readings was taken. The figures are shown in graph No. 1, and it will be observed the relation is linear.

Since heptane is difficult to obtain a special narrow distilling range petrol was now substituted. The petrol is that actually employed in the dehydration of alcohol by the Allinet modification of Young's process. Before use in these experiments, however, it was shaken out with three volumes of 98 per cent. sulphuric acid to remove aromatic hydrocarbons.

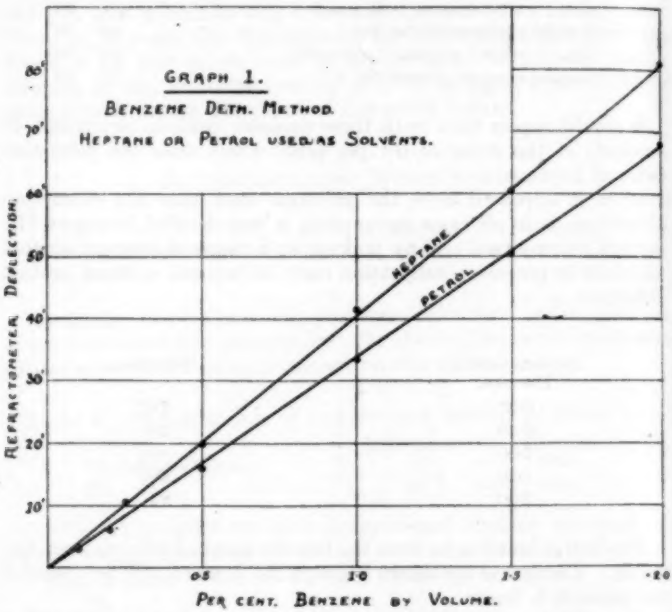
A preliminary experiment with the first lot of petrol prepared gave a deflection of 75′ for 2 per cent. of benzene, but on a

second larger sample of washed petrol only 68′ deflection was obtained:—

9.

Benzene taken. Per cent.		Deflection.
0·1	..	3′
0·2	..	6′
0·5	..	16′
1·0	..	33½′
1·5	..	50½′
2·0	..	68′

These figures are shown in graph 1. The relation is linear within the error of experiment. Some experiments were now made



to determine if any of the arbitrary quantities in the test are at all critical.

10 1 per cent. of benzene used in all cases:—

	Deflection.
Ordinary test	32½′
Dilution water at 40° C.	30′
200 plus 50 c.c. dilution water used	28′
30 min. standing instead of 5 min.	33′

It would appear that the temperature and volume of the dilution water are not at all critical. Reasonable care must, of course, be taken to keep conditions as nearly as possible constant between calibrations.

An important question was the possible effect of water in the alcohol. Some alcohol was therefore diluted to 95 per cent. volume and tests made.

11.

Benzene taken. Per cent.		Deflection.
1	..	34′
2	..	68′

The strength of the alcohol thus appears to have no effect within the practical limits 95 per cent.—100 per cent. This is of course an enormous convenience since no water correction has to be applied.

The use of the petrol as employed in the manufacture has an advantage not stated before. The presence of any residual petrol in the alcohol will have little effect on the benzene determination supposing the actual amount of petrol in the sample to be small. For example, suppose the sample contained 1 per cent. of benzene and 0·5 per cent. petrol. The actual amount of benzene found would be between 0·95 per cent. and 1·0 per cent. The method could probably be extended to determine the actual amounts of petrol and benzene present by using 5 c.c. of benzene as the extracting fluid and determining the fall in refractive index of the latter.

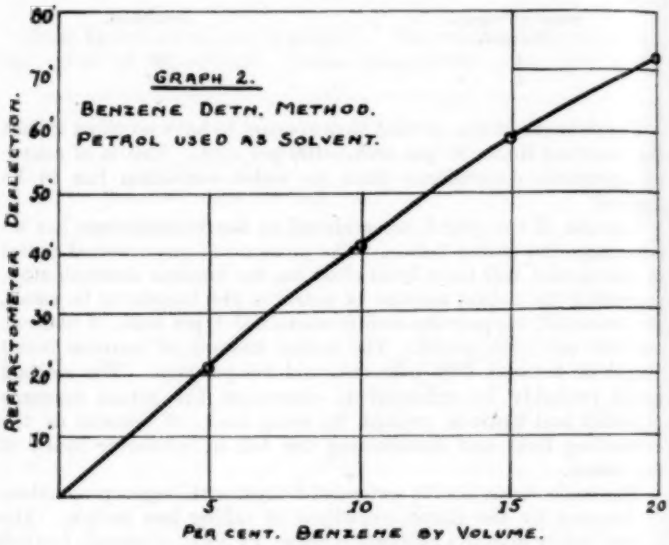
The method can also be extended to deal with larger proportions of benzene by the simple expedient of taking less sample. The figures below give the calibration curve for 5 c.c. of sample instead of 50 c.c., all other quantities remaining as before.

Benzene taken. Per cent.		Deflection.
5	..	21′
10	..	41′
15	..	59′
20	..	72′

The relation is not linear (graph 2) but no doubt would become more nearly so if the dilution water were cut down proportionately.

Summary Part I.—A method has been devised for the determination of benzene in solution in alcohol of 95 per cent. vol.

strength upwards. The water content of the alcohol up to 5 per cent. is without effect on the test. A determination can be made in about ten minutes. The accuracy of the test is about 2 per cent. of the benzene present and the method as described using 50 c.c. of sample is sensitive to 0·03 per cent. Greater sensitivity might be obtained by decreasing the proportion of extracting petrol.



The presence of small quantities of petrol in the alcohol is without appreciable effect and a method is indicated whereby the petrol content itself might be determined.

Part II. Determination of Petrol.—In the preceding part of this note it was indicated that petrol could be determined by extracting with benzene and determining the diminution in refractive index of the latter. In order to get some idea as to the probable range of the refractive index of the petrol left in the alcohol in the course of distillation the following experiment was made. A small quantity of the petrol was distilled from a flask making ten equal fractions

and the refractive index of each fraction determined giving the following figures:—

Original petrol, n_D 20° C.	=	1·409
Fraction 1		1·405
2		1·406
3		1·406
4		1·407
5		1·408
6		1·408
7		1·409
8		1·410
9		1·411
10		1·419

It would appear from the above figures that the variation to be expected is but small. The refractive index of benzene being 1·501, the difference for the original spirit is 0·092. If the residual petrol in the alcohol is as heavy as the last 10 per cent., the interval will be ·082. Hence, if we assume that the residual petrol in practice has the same refractive index as the original petrol, it is unlikely that an error greater than 10 per cent. will be made in the determination. The process being cyclic moreover, it is likely that the small amount of heavy tail will soon be worked out of the petrol.

The dilution and extraction method was now tried, the only alteration made being that 225 c.c. of dilution water was used instead of 150 c.c., since it has already been shown in the paper mentioned before, that dilution with 4½ volumes of water throws out the maximum volume of benzene. The following readings were taken:—

Original benzene	4°	6′
Do. after shaking with water	4°	6′
Blank on alcohol No. 1	4°	17′
„ „ „ 2	4°	11′
Do. after further water wash	4°	11′
Deflection for 1% petrol		87′
„ „ 2% „		165′

The deflection thus appears to be roughly proportional to the amount of petrol taken and the method appears very sensitive.

The magnitude of the blanks is a matter for surprise.

Alcohol No. 1	= 11′	= 0·13%	"petrol."
„ 2	= 5′	= 0·06%	„

No. 1, as already stated, is a sample dehydrated by the Allinet process, but No. 2 is a sample of ordinary commercial absolute

alcohol stated to have been dehydrated by lime. It is possible that the "petrol" figures arise from the presence of amyl alcohol, since "fusel oil" has a refractive index of about 1·39. The amounts, however, seem somewhat larger than would be expected. Obviously further samples of alcohol of known origin should be tested, and in the meantime the figures from the two samples already tested are given below for future reference.

Sample.	"Benzene."	"Petrol."
	%	%
1	0·10	0·13
2	0·05	0·06*

Since the petrol employed in the Allinet process contains aromatics to the extent of 7 per cent., these will be included in the benzene determination. Hence it would probably be better to use sulphuric washed petrol for standardising the petrol determination method.

Determination of Waters. Part III.—Assuming that the benzene and petrol content of an alcohol sample can be determined by the foregoing method the determination of one more physical constant should suffice to give the water-content of the sample. A direct chemical method would, of course, be preferable, but apart from the use of barium ethylate which has not yet been tried, one did not suggest itself.

The following table gives the physical methods of which trials were made. Each method is discussed afterwards.

Method.	Accuracy.	% H_2O.	Effect of 1% benzene.
Density	0·0001	0·02	0·12% H_2O
Separation temp., ° C.	0·2	0·01	0·06% "
Solubility NaCl, c.c.	0·05	0·04	0·16% "
Refraction	0·0001	0·2	2·4% "

Density.—The determination of density (or more usually of specific gravity) is the basis of alcoholometry for fiscal purposes and hence must be regarded as the standard method when dealing with alcohol water mixtures for testing any other method. To obtain results reliable to four significant figures temperature control to 0·05° C. is necessary, and a determination cannot well be carried out in less than 20 minutes at the very least.

The density and refractive index of the system benzene-water-alcohol have been investigated by Bartholdy, but the accompanying

* The following samples have since been tested:—

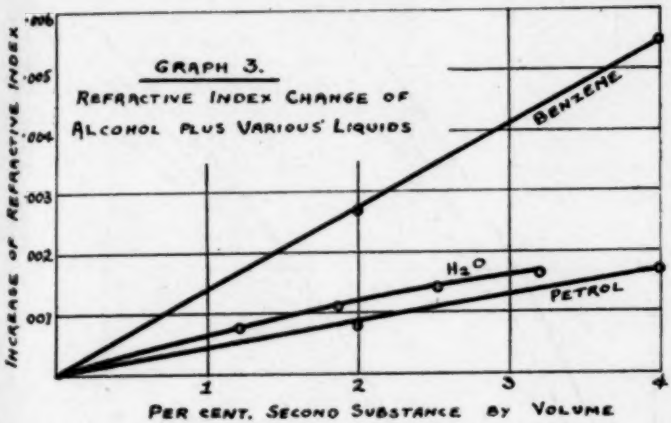
Sample.		"Benzene."	"Petrol."
3	"A.R." quality	nil	0·03
4	Lime dried	0·05	0·04

graph No. 3, constructed from some measurements made in the course of this work, shows the effect of the addition of small amounts of water or petrol or benzene on the refractive index.

Two benzene-water-alcohol mixtures were made up. The density and benzene content were determined and the density corrected at the rate of ·0009 for each 1 per cent. of benzene present. The results were :—

	1.		2.	
	Taken.	Found.	Taken.	Found.
Benzene	1·77%	1·73% ..	0·50%	0·52%
Water	0·14%	0·14% ..	2·14%	2·21%

The method has the advantage that water has an eight times greater effect on density than has benzene, hence an error in the determination of the latter is not serious.

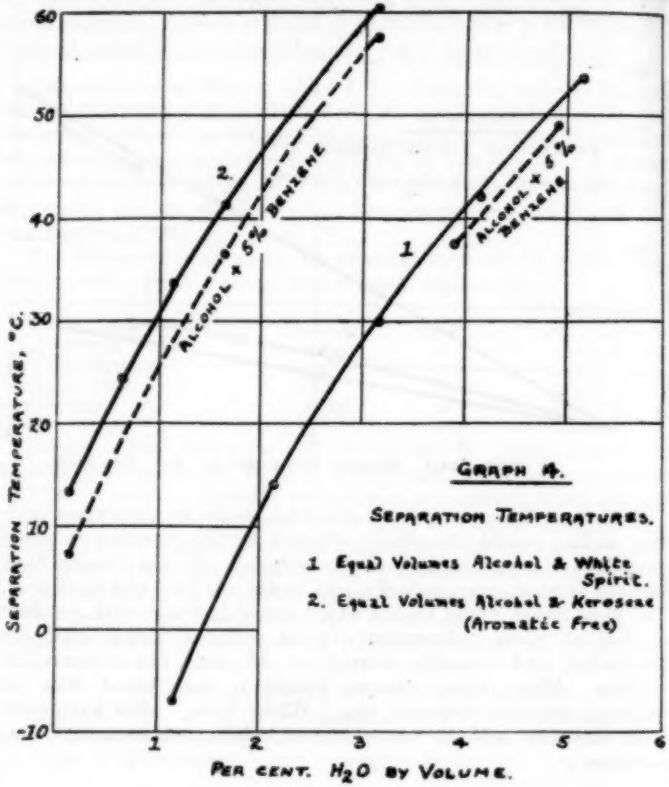


Separation Temperature.—It has been shown in a previous note that aniline points are greatly affected by the presence of small quantities of water in the aniline employed. It was thought that perhaps an analogous method might be devised for water in alcohol. The ideal liquid would be one which would just mix with absolute alcohol at room temperature (equal volumes being used for simplicity) and separate sharply on dropping the temperature slightly. After trying various liquids it was found that an ordinary domestic kerosene like "White Rose," after extraction with sulphuric acid to remove unsaturateds and aromatics, was suitable.

The following separation temperatures were noted using 10 c.c. of alcohol mixture and 10 c.c. of the washed kerosene.

% Vol. water.		% Vol. benzene.		Separation temp., ° C.
0·14	..	0	..	13·5
0·14	..	5	..	7·2
0·64	..	0	..	24·3
1·14	..	0	..	33·5
1·64	..	0	..	41·6
1·64	..	5	..	36·5
3·14	..	0	..	60·5
3·14	..	5	..	57·7

The separations were very sharp and could probably be determined to 0·1° C. with care. The separation temperature curves are shown in the accompanying figure No. 4. It will be noticed



the effect of benzene is but small, as already stated only 0·06 that of water. It is probable that the effect of the light petrol would be of the same order. At any rate it will certainly be in the same direction, namely, to lower the separation temperature.

Solubility of Sodium Chloride.—This method does not appear to be so good as the two preceeding methods, the effect of benzene being undesirably large. "Pure" sodium chloride solution was mixed with an equal volume of pure concentrated hydrochloric acid and the precipitated salt filtered off, dried and heated to 500° C. in order to remove any remaining HCL. This last step was found to be very important in obtaining concordant results. About ·25 gms. of the finely ground purified salt was stirred vigorously with 30 c.c. of the aqueous alcohol in a 1″ tube which was kept in a water bath maintained at 25° C.∓0·05. After stirring the solution was filtered, 25 c.c. of the filtrate diluted with 100 c.c. of water and titrated with $\frac{N}{20}$ silver nitrate. Preliminary tests were made stirring for 5 minutes, 10 minutes and 2 hours. It was found that saturation occurred between 10 and 30 minute periods. In all subsequent tests therefore a half-hour period of stirring was employed. The results obtained were as follows :—

Vol. % water.	c.c. $\frac{N}{20}A_gNO_3$.	NaCl g. per 100 c.c.	c.c. A_gNO_3 calcd.
0·14 ..	4·5 ..	0·0526 ..	4·50
1·14 ..	5·85 ..	0·0684 ..	5·82
2·14 ..	7·45 ..	0·0872 ..	7·46
3·14 ..	9·3 ..	0·1088 ..	9·40
5·14 ..	14·2 ..	0·1661 ..	14·21

The figures in the last column are calculated from the empirical formula :

$$N=4{\cdot}34+1{\cdot}125W+0{\cdot}154\ W^2$$

N=c.c. $\frac{N}{20}$ silver nitrate

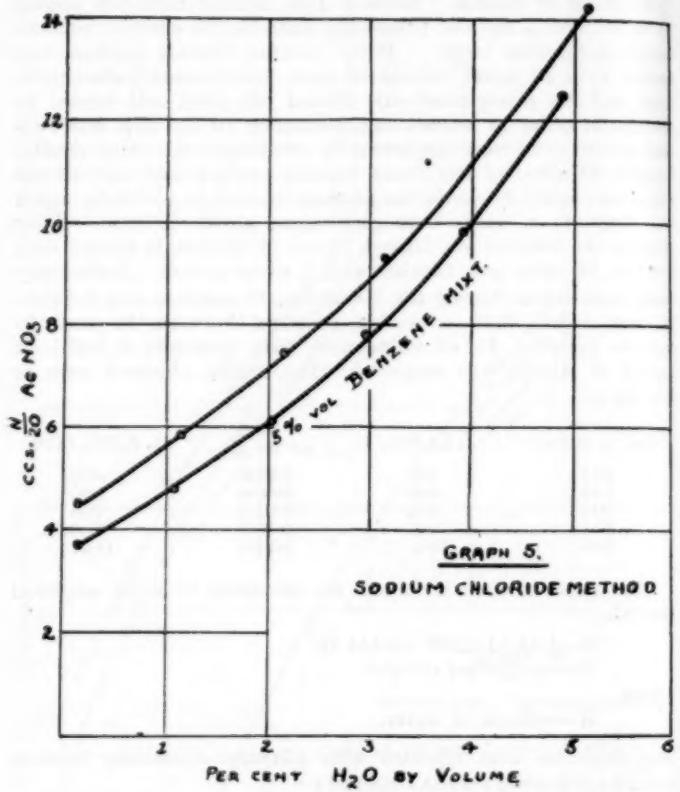
where

W=volume of water.

The measures were repeated with mixtures containing benzene and the following results obtained :—

% vol. water.	% vol. benzene.	c.c. $\frac{N}{20}A_gNO_3$.
0·13 ..	5·00 ..	3·7
1·08 ..	5·00 ..	4·8
2·03 ..	5·00 ..	6·1
2·98 ..	5·00 ..	7·8
3·93 ..	5·00 ..	9·85
4·88 ..	5·00 ..	12·5

The figures in the presence and absence of benzene are plotted in the accompanying graph No. 5. It will be observed that the curves are not parallel, the effect of benzene being greatest about the middle of the curve and less at each end. This would complicate any method for the determination of water based on salt solubility.



The effect of benzene is moreover greater than in the density or separation temperature methods.

Refraction.—It is obvious that direct determination of refractive index with any ordinary instrument will be of little service, the change of refractive index with water being so small. With an

interference refractometer however the measures could be taken with great accuracy but the difficulty of the large effect of benzene would still remain. Some indirect method seems to be indicated therefore. Possibly by shaking with potassium carbonate or the like a change of refractive index could be obtained which might bear some relation to the water content. It is hoped to experiment on these lines in the near future.

The authors wish to acknowledge the financial assistance received from the Distillers Company, Limited, and the Fuel Research Division of the Department of Scientific and Industrial Research towards the expenses of this research.

Further Experiments with the Moore Ignition Meter.

By W. R. Ormandy and E. C. Craven (Members).

The determinations recorded below have been made in the intervals of other work. No claim is made for any completeness in the work, but it is felt that little progress can be made without altering radically the design of the instrument, and therefore it may be advisable to put on record the further determinations with the existing meter.

As stated in previous notes the ignition meter used is similar to that described by Moore with the exception that the explosion chamber has a somewhat greater volume. The oxygen employed was prepared electrolytically in the earlier stages of the work in which case the gas was purified by passage through heated granular copper oxide. Later on the gas was prepared by means of permanganate and acidified hydrogen peroxide.

Heptane, being the only aliphatic hydrocarbon of good purity which can be obtained in fair quantity, was used as a more or less standard liquid in various tests. In earlier papers we have given the spontaneous ignition temperature (hereafter denoted by S.I.T.) as 245° C. In more recent work the value 250° C. was obtained, but by removal of the last traces of hydrogen from the oxygen employed this value was increased to 253° C. The foregoing values were obtained by heating the block with a ring gas burner. Later, in order to raise the block to high temperatures, it was provided with a michrome wire winding and heat insulated on sides and bottom by alundum cement and clay. Under these conditions the value 243° C. was obtained. These figures illustrate the fact that whilst in any one run the ignition temperatures can be obtained to 1° C. slight alterations of conditions may give very appreciable differences in the results obtained. In the last note it was pointed out that reducing the volume of the explosion chamber from 38 c.c. to 16 c.c. raised the S.I.T. from 245° C. to 278° C. Moore with a chamber volume of 24 c.c. found 281° C. It is likely however that the latter high value is to be ascribed to the presence of naphthenes in the heptane employed. For example a sample of Heptane (Kahlbaum) gave an S.I.T. of 284° C. (gas heating) but this contained 46 per cent. of naphthenes.

Attempts were made to influence the S.I.T. of heptane by copious infra red radiation into the explosion chamber by focussing the image of the crater of an arc between carbons into the explosion

chamber, by means of a large silver on glass mirror. The results were negative. Similar lack of effect was obtained by bringing the arc within a few inches of the explosion chamber cover. It was thought at one time that some effect was obtained when a red hot carbon rod was brought very close to the cover opening, but this result could not be substantiated.

Raising the block to a potential of 200 volts was without effect as was also the introduction of a central wire at 200 volts with respect to the block. Two small nickel foil electrodes a few millimetres apart with a potential difference of 60 volts introduced into the explosion chamber were without effect on the S.I.T. of heptane and no considerable ionisation could be detected until explosion actually occurred.

An attempt was made to dry heptane and a petrol intensively by standing an open vessel of each liquid over phosphorus pentoxide. The oxygen was dried by successive towers of calcium chloride and phosphorus pentoxide. The following figures were obtained:—

	Time of drying.	S.I.T., °C. Dried.	S.I.T., °C. Undried.
Heptane	0 days	—	243
	6 „	243	243
	6 months	244	243
Petrol	0 days	—	282
	6 „	282	282
	6 months	279	279

No certain effect was therefore produced by the drying. On determining the boiling point of the dried heptane by distillation, however, the boiling point appeared to be within 0·01° C. of the undried. No measurable association had therefore taken place. The experiment may be repeated with the heptane actually in contact with the pentoxide. The petrol resinified slightly in the course of the six months standing and the slight fall in S.I.T. is probably due to this.

The following ignition temperatures have been determined by gas heating, except where otherwise stated.

Petroleum Fractions—	S.I.T., °C.	Remarks.
Pentane (Kahlbaum)	292	Fairly pure
33–34° C. petrol fraction	295	
34–35° C. „ „	292	
35–36° C. „ „	290	
Hexane (Kahlbaum)	286	About 50% naphthenes
67–68° C. petrol fraction	280	
68–69° C. „ „	280	10–20% naphthenes
69–70° C. „ „	281	
70–71° C. „ „	283	
Iso hexane	284	
2-Methyl pentane	275	
2-Ethyl butane	273	Impure

	S.I.T., ° C.	Remarks.
Petroleum Fractions—		
Heptane (Kahlbaum)	284	About 50% naphthenes
Pratt's petrol	281	
„ „ plus 1% $SiCl_4$	279	„
„ „ plus 1% $TiCl_4$	271	
Hydrocarbons—		
Heptane (ex Pinus S.)	253	
„ „	243	Electrical heating
Cyclohexane	296	
Methyl cyclohexane	285	
Hexahydroxylene	279	
Tetraline	414	
Decaline	267	
Pinene	275	
Spinacene	260	
Squalene	258	
Benzene	639	Electrical heating
Toluene	582	„
m-Xylene	593	„
S-Trimethyl benzene	509	„
Amyl benzene	255	
Naphthalene	602	Electrical heating
Phenanthrene	570	„
Phenols—		
α naphthol	537	„
β „	550	„
Thymol	340	
Alcohols—		
Methyl	488	
Ethyl	329	
„ 97·5% vol.	333	
„ 94·2% vol.	345	
Iso propyl 0·803	484	
(3 samples) 0·808	500	
0·822	505	
n-Butyl	328	
iso-Butyl	326	Impure
iso-Amyl	323	„
n-Hexyl	300	„
Cyclohexanol	322	
Benzyl alcohol	373	
Miscellaneous—		
Acetaldehyde	191	
Acetic acid	564	Electrical heating
Ethylene glycol	407	„

The following have ignition temperatures above 500° C.:—Anthracene, phenol, hydroquinone, pyrogallic acid, and acetone.

It may be noticed, in some cases, that the values given for aromatic hydrocarbons are much higher than those given by Moore. These differences are due to the use of more nearly pure materials. Except where otherwise stated in the above table the degree of purity was considered to be such that further purification would not materially affect the ignition temperatures. In regard to determinations above 500° C. it must be pointed out that a very brisk oxygen stream appears to be essential to give

consistent minimum results. If the oxygen flow be restricted to one or two bubbles per second the liquid introduced appears to undergo slow combustion without bursting into flame.

In general the results confirm the broad deductions which have been drawn from previous work, and in addition indicate that the saturation of double bonds leads to a decrease of ignition temperature. Consider for example:—

	S.I.T., ° C.
Naphthalene	602
Tetraline	414
Decaline	267

and also benzene, toluene, xylene and their hexahydro derivatives.

The first effect of a single hydroxyl substitution appears to be a reduction of ignition temperature in the aromatic group whether the substitution takes place in the ring or a side chain (*e.g.*, benzyl alcohol).

With the paraffins an increase of ignition temperature appears to result and probably the same is true for a second hydroxyl substitution. It may be objected, of course, that methane for example has a higher ignition temperature than methyl alcohol, but this is probably owing to the fact the former has to be fed in as a gas which is a factor the effect of which can hardly be estimated. In connection with this last point some experiments were made with heptane in order to determine if introduction as a vapour instead of in the liquid form would make any difference to the determined S.I.T.

A glass bulb was fitted with a tap and a capillary bore delivery tube, the latter being electrically heated to well above the boiling point of heptane. Some heptane was introduced into this miniature boiler and boiled to displace air, after which the tap of the delivery tube was closed and a small pressure of heptane raised in the bulb. By turning on the tap a puff of heptane vapour could be introduced into the ignition meter at will.

A second and simpler expedient was also employed. A small pellet of asbestos wool on the end of a fine wire was wetted with heptane and introduced into the meter avoiding any contact with its walls.

The results from both methods were practically identical, *namely*, to show that the S.I.T. was raised only 5° C. by the substitution of vapour for liquid. The asbestos torch method was particularly informative since often on withdrawing after the explosion it was observed that the heptane had not entirely evaporated.

It is a question of considerable interest what significance can be attributed to the temperatures determined by the Moore meter. This involves the question of the reactions taking place. It has

sometimes been supposed, for example, that the ignition point determined is not that of the hydrocarbon introduced but of its decomposition products. This hypothesis seems however rather to beg the question since the final result is still a function of the body introduced, whatever the intermediate steps. Moreover the general trend of cracking is towards the formation of hydrogen, hydrocarbons of molecular weight lower than that of the original body and a residue of so-called carbon. The hydrogen and light hydrocarbons will have ignition temperatures above that of the original heavier hydrocarbon. This will be so the more probably since the cracking products are partly of an unsaturated nature. In regard to the carbonaceous residue there is no evidence that this is particularly effective in initiating the ignition. Most forms of amorphous carbon have ignition temperatures above that of a petroleum spirit. Asphaltic carbons from lubricating oil as well as " hard asphaltum " have ignition temperatures above that of heptane. Finally, it may be noted that in some density measurements by the Victor Meyer method made in air at 220° C. and upwards a residue of brown " carbon " is left whilst part of the heptane vapour is combusted.

It would appear that the best way of regarding the whole matter is as follows : —

The Moore ignition point is the temperature of an isothermal enclosure at which the rate of heat evolution from a combustion reaction taking place within it, exceeds the rate of heat loss. In experiments published previously it has been shown that the temperature of the reacting mixture at the moment before the slow combustion develops into ignition, is considerably above the temperature of the meter. As to the nature of the preliminary reaction no doubt a great variety of intermediate products are formed, but in experiments in which heptane and oxygen were passed over iron just below the ignition temperature only water and carbon dioxide could be detected. The Moore ignition temperature is therefore probably a function of the velocity co-efficient of the complete combustion reaction.

The authors wish to acknowledge the financial assistance received from the Fuel Research Division of the Department of Scientific and Industrial Research towards the expenses of this research.

Fifth International Road Congress.

Report by PERCY EDWIN SPIELMANN, Ph.D., F.I.C.

The Fifth International Road Congress, under the Presidency of Senator Professor Dr. Luigi Luiggi, D.Sc., M.Inst.C.E., was held in Milan and Rome from September 5th to September 13th, 1926. It was attended by about 2000 delegates from various countries, and was held in the Palazzo della Facoltà Giuridica.

The various sessions were divided into two Sections and six Questions, as follows :—Section I. : Question 1, Concrete Roads ; Question 2, Bituminous and Asphaltic Roads ; Question 3, Standardization of Tests for Road Materials. Section II. : Question 4, Census of Traffic ; Question 5, Development and Planning of Towns in Interests of Traffic ; Question 6, Special Roads Reserved for Motor Traffic. Reports were submitted before the date of the Congress and distributed together with "Conclusions," which consisted of discussion of the reports and final deductions made from them. It was these deductions that were discussed at the various sessions. From the outset it was clear that considerable confusion existed between the reports as a result of the variations of nomenclature used for bituminous materials, and great care was necessary to realise exactly what meanings were intended.

The following matters are the more interesting to this Institution :—

Section I., Question 2 : Bituminous and Asphalt Roads.
Natural Road Asphalt : 1st Conclusion.

"(*a*) The asphaltic rock must be homogeneous and free from any foreign substance, entirely impregnated with bitumen, and must not contain clay in any appreciable quantity. It is recommended that the maximum limit be 2 per cent. estimated in oxide of alumina.

"(*b*) The percentage of bitumen, which may vary between wide limits from 6 to 13 per cent., must be controlled according to the climate and traffic, remaining within the lower limit in very hot climates and very heavy traffic, and within the higher limit in the reverse case."

Mr. P. J. M. Larranaga asked the meaning of the word "controlled" in paragraph (*b*), pointing out that the natural rock varies in the quantity of bitumen present. After further discussion it was decided that natural Rock Asphalt could consist of rock blended as

to its various bitumen contents, together with any required addition of pure bitumen, and still be called "natural."

Non-Asphaltic Mineral Materials: 2nd Conclusion.
Bituminous Binding Material: 3rd Conclusion.

"(*a*) The tests at present in use for bituminous materials, are sufficient, on the whole, to ascertain whether a given bitumen is suitable for a given road under given conditions. The Congress, however, expresses the desire that a practical method may also be found of measuring the adhesion of a bituminous binding material to an aggregate, and that a complete study should be made of the action of the very fine mineral matter incorporated in bituminous binders, on the so-called asphaltic characteristics of the binding material itself.

"(*b*) The penetration figure, usually determined at 77° F., or 25° C., although it may be taken as sufficient to ascertain the constancy to type of a bituminous binding material, provided that the origin and method of preparation are also constant, is not sufficient to give the suitability of such a material to the requirements of a given use. It is recommended to add to specifications for bituminous binding materials, the softening or melting point, obtained for preference by the ball and ring method.

"(*c*) The ductility test, carried out at the one temperature of 25° C., is, in certain cases, of little significance. It is recommended to add to the specifications a lower temperature test—say at zero—and also a test at a higher temperature, when dealing with bitumen which, at a temperature of 25° C., give an elongation not exceeding 50 centimetres.

"(*d*) For asphaltic binding materials, it is recommended that the asphaltenes be determined by solution in naphtha or petroleum ether. When standardising the methods of testing bituminous materials, it will also be necessary to define the character of this solvent, to specify its nature, its density and the limits of distillation."

It was urged by the Swiss delegate, and accepted by the meeting, that the asphaltene determination should always be accompanied by a determination of paraffin wax, and that naphthalene should be used for the purpose.

"(*e*) The penetration figures, suitable for the various bituminous roads, vary considerably according to the method of execution, the climate, and also the quality and intensity of traffic to which they are subjected. The degree of penetration must decrease in proportion with greater compactness in the mixture, greater fineness of aggregate, greater heat and dryness of climate, and greater intensity of traffic.

"It is impossible to state—*a priori*—the figures corresponding to each combination of these variable factors. The particular cases, however, mentioned in the reports to the Congress, may well serve as a guide for rough approximation, the assistance of local experience being necessary in any case.

"(*f*) Superficial applications of bitumen on water bound macadam are more successful if preceded by an application of tar. The mixture of a tar with a fluid bitumen facilitates this superficial treatment and makes it more effective and durable.

"The addition of tar to an asphaltic binding material, when making asphalt concrete, makes the road surface rougher and makes it possible to apply the mixture at a lower temperature. There is therefore good reason for a closer study of these mixtures of bituminous binders with tar and its derivatives, either for improving the conditions under which use is made of the materials themselves, or for the sake of economy in bituminous conglomerates, whenever the cost of tar and derivatives is considerably lower than that of bitumen."

Mr. J. S. Killick proposed that the first four lines should be replaced by others stating that in exceptional circumstances, when water bound macadam is friable and dusty, priming coats may be employed consisting of creosote oil and rock oils and light tars. Mr. Marriott proposed the omission of the first three lines of the second paragraph (which were based on Swiss experience) and the insertion of a statement regarding the reciprocal use of tar and bitumen.

These resolutions brought about much discussion, particularly among the tar interests, and to avoid a split in the British vote an amended resolution was proposed, stating that in several countries good results were obtained by a preliminary coating of tar on macadam before the application of a coating of bitumen; also, that a mixture of tar and bitumen is satisfactory for use on a dusty water bound macadam. Mr. W. J. Hadfield accepted that amendment as a necessary compromise on behalf of the British Delegation.

Section I., Question 3: Standardization of Tests for the following Road Materials—Coal Tar, Bitumens and Asphalts.

At the last moment the printed "Conclusions" were modified to the following:—

"The Congress is of opinion that a Committee should be appointed by the Congress with a mandate:

"(*a*) To establish a uniform nomenclature for all the principal materials and methods employed in road making.

"(*b*) To standardize the methods of taking samples and for their examination.

"The appointment of this Committee is to be made by the President of the Congress acting with the Central Bureau of the Permanent International Association of Road Congresses, it being understood that in this Committee there will be represented the four languages recognised at the Congress, together with Spanish and a Scandinavian language, and that the members of the Committee shall be, as far as possible, representatives of the National Associations established for this purpose in the various countries."

It is to be noticed that although Question 3 dealt with Standardization of Tests, much greater prominence was given to the Standardization of Nomenclature.

Speaking on behalf of the British Delegation, and in support of these conclusions, the writer urged that the Committee should be as small as possible and that headquarters should be in Paris.

Claims for the recognition of the Czecho-Slovakian and Dutch languages were then made, and for the representation of Rumania on the Committee. Eventually a small Committee was decided on, requiring three languages,* with powers to add consultative members and with headquarters in Paris.

The Road Exhibition, occupying part of the ground used for the annual Milan Fair, was small but well arranged. The British Pavilion contained models and maps illustrating the activities of the Ministry of Transport, and the bitumen and asphalt interests were well developed.

* This is in accordance with my notes but not with the official summary in proof submitted for correction. P. E. S.

AMERICAN PETROLEUM INSTITUTE.

Proposed Projects in Research in Petroleum.

A programme of scientific research in geology, physics and chemistry of petroleum was initiated by Mr. John D. Rockefeller by the grant of $250,000 in five annual instalments of $50,000, and a similar grant was also made by the Universal Oil Products Company.

The advice and co-operation of the National Research Council of Washington, D.C., was obtained and a Central Petroleum Committee formed. The following particulars of some of the proposed projects put forward are abstracted from Bulletins Nos. 43 and 65, dated June 30th and October 25th, 1926, of the American Petroleum Institute.

Under the heading of Physics it is proposed to accurately determine the physical properties of a large number of crude petroleums and products, this being combined with the Separation, Indentification and Determination of the Chemical Constituents of Commercial Petroleum Fractions. Straight-run commercial fractions will be fractionated and the fractions obtained subjected to (*a*) fractionation by isothermal evaporation at different temperature levels; (*b*) fractional crystallization by cooling; (*c*) fractional crystallization from solutions in solvents; (1) by cooling and (2) by isothermal evaporation, and (*d*) fractional precipitation from one solvent by addition of another.

The separation and chemical identity of the final products should be established by (1) freezing behaviour; (2) equilibrium boiling-point; (3) crystallographic examination; (4) combustion analysis; (5) molecular weight, and (6) conversion of pure material into a chemical derivative and identification thereof.

The above should be carried out in a quantitative manner and empirical formulæ of the pure substances determined. Further investigation of their properties and structural formulæ should be made by an organic chemist.

Under chemical problems for solution are the Preparation of Pure Typical Hydrocarbons and a Study of Their Behaviour when Heated Alone and with Catalysts. Pure hydrocarbons will be prepared and subjected to varying heat conditions to ascertain

(1) possible rearrangement and polymerisation of olefines and (2) possible rearrangement and decomposition of paraffins and cyclo paraffins.

A special Study is outlined of the Cyclopentane Fraction of Southern California Petroleum. Halogen derivatives of pure cyclopentane will be prepared and, by the Grignard, Fittig and other reactions, involved in combination with aliphatic groups and complex substituted cyclopentanes built up.

Another important line of investigation will be the Isolation and Investigation of Thermo Labile Hydrocarbons Present in Petroleum. Through the formation of organo-metallic compounds it is proposed to isolate the labile hydrocarbons and to study their derivatives.

It is suggested that by the Effect of Electric Discharge upon Gaseous Hydrocarbons useful information may be afforded. These lower hydrocarbons might be circulated past a zone of corona discharge, or through an ozonizer, the resultant products being collected by refrigeration if liquid and by filtration or precipitation if solid. It would be interesting to know whether hydrocarbons could be entirely removed from the gaseous phase by this process, leaving hydrogen sufficiently pure for industrial uses.

The Analysis of Hydrocarbons by the Time Positive-Ray Method is another suggestion. Apparatus has already been designed for this and may open up for solution a large number of important problems.

Further chemical investigations include a Study of the Relative Rates of Reaction of the Olefines. Data on the rates of oxidation, hydrogenation and halogenation of the olefines will be sought by the use of a bubbling absorber and measurement of reaction co-efficients for olefine absorption by various reagents, and the Catalytic Transformation of Unsaturated Aliphatic Hydrocarbons into the Corresponding Alcohols. It is proposed to study the physical conditions most suitable to attaining direct hydration of ethylene and ethylene hydrocarbons in the presence of well-known catalysts.

An important line of investigation is on the Action of Sulphuric Acid on Hydrocarbons. The constitution of a number of sulphuric acids derived from the action of sulphuric acid on hydrocarbons will be studied. The action of more dilute acid than fuming sulphuric acid will also be investigated.

The investigations proposed on the Sulphur Compounds in Petroleum should afford valuable information. The suggestions begin with a Study of the Reactions of a Number of Selected Organic Sulphur Compounds. Starting with pure organic sulphur compounds it is proposed to (1) collect literature relating to their

reactions; (2) try known reactions on representative compounds of all types and endeavour to discover others, and standardise the most promising reactions, and (3) repeat these reactions with known dilutions of organic sulphur compounds in suitable hydrocarbons or hydrocarbon mixtures.

The Isolation and Study of the Sulphur Compounds Present in Petroleum, with the Determination of Physical and Chemical Properties of all Types of Sulphur Compounds Present in Petroleum follow. Two lines of attack are proposed: (*a*) Analytical, involving a qualitative scheme for detecting type sulphur compounds, among those to be considered being: Hydrogen Sulphide, Elementary Sulphur, Carbon Disulphide, Mercaptans, Alkyl Sulphides, Alkyl Disulphides, Thiophene, Sulphonic Acids, Sulphoxides, Sulphones and Alkyl Sulphates; (*b*) Isolation of Sulphur Compounds. Having isolated compounds, they could be fractionated under reduced pressure and the final close fraction tested to determine if the compound is pure.

Comparatively little is known of the nitrogen compounds in Petroleum. Their isolation and investigation is suggested from Californian petroleum and will involve (1) separation of bases into fractions, (2) resolution of fractions into components, (3) catalytic reduction by Skita method, (4) use of dehydrogenisation on fractions of nitrogen bases where hydrodes of methylated quinolines are suspected, (5) oxidation of fractions and search for pyridine pentacarboxylic acid, methyl pyridine tetracarboxylic acid and beta-methyl quinoline, with a comparison of these products, (6) ring cleavage of pyridine and benzene nuclei, (7) reduction by Skita method of Combes' 2, 3, 4-trimethyl quinoline to prepare tetra- and decahydrides, (8) synthesis of heptamethyl quinoline and its catalytic reduction, and (9) a search for nitrogen compounds other than quinoline derivatives.

The Study of the Metallic Constituents of Crude Petroleum will involve the combustion of a large volume of oil under conditions suitable for complete ash collection.

Amongst many other problems on which suggestions are made are:—

The Determination of Geothermal Gradients in Oil Fields in Anticlinal Structures. Temperature observations will be made in selected fields in Texas, Oklahoma and California.

The Displacement of Petroleum Oils from Oil-Bearing Sands by use of Selected Aqueous Solutions. The stability of solid suspensions in binary liquid systems and the relative wetability of solids by liquids will be studied.

The Analysis by Fractional Distillation from Absorbent Materials (Charcoal, Silica Gell, etc.), both of Light and Heavy Members of

the Hydrocarbon Series. Absorbent agents will be used for separating hydrocarbons more or less closely related as to boiling-point, melting-point and solubility in ordinary reagents.

Reactions during "cracking" should be elucidated, or at least our knowledge materially advanced by investigations of the Catalytic and Non-Catalytic Thermal Decomposition of Pure Hydrocarbons and Related Compounds. The nature of organic thermal decomposition of both saturated and unsaturated hydrocarbons will be studied.

Finally, mention may be made of the proposals relating to the behaviour of Fuels in Internal Combustion Engines. By the Analysis of the Gradual Oxidation prior to Ignition of Fuels in Internal Combustion Engines, information will be afforded on the Relation of such Oxidation to Detonation. An apparatus has been designed for taking a sample of gas from the cylinder of an engine at any instant of the cycle.

STUDENTS' SECTION, LONDON BRANCH.

A MEETING of the London Branch of the Students' Section of the Institution of Petroleum Technologists was held at Aldine House, Bedford Street, London, W.C. 2, on October 19th, 1926, the following being a brief abstract of the paper read:—

Conditions Governing the Occurrence of Oil in Burma.

By L. DUDLEY STAMP, B.A., D.Sc.(London), A.K.C. (Associate Member).

SINCE Dr. E. H. Pascoe published his memoir on "The Oilfields of Burma" (*Mem. Geol. Surv. India*) in 1912, much geological work has been carried out in Burma but relatively few of the results given to the public.

The oil-bearing rocks of Burma are of Tertiary age and occupy the site of a long narrow arm of the sea which was filled up during the Tertiary period. The oilfields are situated on anticlinal flexures near the centre of the old gulf, and so form a long line from north to south. The more important fields are Indaw, Yenangyat, Singu, Yenangyaung, Minbu (comprising the separate fields of Minbu, Palanyon and Yethaya), Padaukpin, Yenanma and Ngahlaingdwin. Brief notes were given on the history and production of these fields, and it was emphasized that the oil occupied many different horizons. The oil sands range in age, in the existing fields, from the upper part of the Eocene to the top of the Peguan (Oligo-Miocene). Reference was made to the long standing futile controversy as to whether "the" oil horizon occurred below or above the "Kama Clay." The Kama Clay is an insignificant local band of clay and has little real significance in Burmese geology, whilst "the" oil horizon is, in reality, many.

Reference was made to the division of the Tertiary sequence into palæontological stages. It was pointed out that the lithological horizons and the oil-bearing horizons crossed the palæontological horizons, and therein lay the explanation of many puzzling features in Burmese Tertiary geology. The oil-sands were not associated with beds of any particular age, but always with beds of a certain type and laid down under definite conditions. The necessary conditions, so far as Burma is concerned, are inter-

mediate between freshwater (lacustrine or fluviatile) and deeper water marine. The necessary brackish water or shallow marine water conditions are indicated in the field by a particular *facies* of fossils. These the ordinary geologist can recognise without being concerned with the details of palæontological nomenclature.

An interesting discussion followed, in the course of which Mr. T. DEWHURST reviewed the earliest history of the Burma Fields and welcomed the opportunity thus afforded of paying tributes to the early geological workers in Burma, notably Dr. T. Oldham and Mr. G. E. Grimes. To Dr. Oldham belongs the distinction of having been the first geologist to recognise the connection between anticlinal structure and the accumulation of oil, which he did at Yenangyaung in the year 1855. He was therefore the father of the well-known anticlinal theory of oil accumulation which has been of incalculable value in the search for and development of oilfields. Mr. G. E. Grimes mapped the Singu structure before any wells were drilled and recognised its possibilities. He (the speaker) also stated that he was under the impression that, the earliest work done on the important problem of the effect of the assymetry of anticlines on the disposition of oil-pools and the problem of the determination of the hade of the axial plane was in connection with the Yenangyat Oilfield. It was therefore gratifying to record that Burma had played its part in the elucidation of the main principles of petroleum geology. He agreed that the oil-bearing Tertiary rocks of Burma had been deposited under the conditions which had been so clearly outlined in the paper, and he also agreed that it followed from a study of the conditions that the time planes would cross the condition stages. Among other matters he raised the question of the age of the "Axials" of the Arakan-Yoma. Where he had seen these rocks they consisted of highly contorted schists and phyllites, and were overlain unconformably by moderately dipping and quite unaltered shales of early Eocene or possibly a slightly greater age. The striking contrast between the diastrophic effects above and below the unconformable junction suggested a considerable time interval between the deposition of the two series.

CORRESPONDENCE.

To the Editor.

DEAR SIR,

I am writing to point out that in a review of my recent book—The Geology of Oil, Oil-Shale, and Coal—published in the latest number of the JOURNAL over the initials E.H.C.C., there are certain misleading statements which are likely to give a totally erroneous impression of what the book is about, and to ask the Publication Committee to be so good as to correct them.

In the review, referring to myself, it is stated:—"He maintains that oilfields are the result of the deposition of petroleum along with argillaceous sediment, that coal seams are . . . . deposited under marine conditions, that lignites on the other hand, have been formed under fresh or brackish water conditions . . . ." The review goes on to say, "All these propositions will, no doubt, be combated on questions of actual fact and observation." Naturally. I combat the propositions attributed to me by the reviewer, which I have quoted above, as strongly as anyone. Unfortunately for the reviewer, nowhere in the book have I suggested that oilfields have been formed by the deposition of petroleum along with argillaceous sediment. What I have said is that a certain type of oilfield (and only one type of several) may have been formed by the deposition of vegetable oil and resinous material by argillaceous sediment, the change into petroleum taking place after deposition had taken place. The probable method by which that change took place is indicated. Nowhere, also, have I drawn the distinction between the mode of formation of coal and of lignite that has been attributed to me by the review.

In the last paragraph of the review there is said to be a serious contradiction on pages 57 (I presume the reviewer means 56) and 67 on the subject of the relation of lignites to oil in Burma, but certainly no one who has read the book carefully will accept the statement that there is any contradiction since pages 56 and 57 refer to the lateral variation of strata in the Eocene system and page 67 to the lateral variation of strata in the Pegu system, two widely separated geological horizons.

Possibly a more careful reading of the book, and an exhaustive study of the geology of the Yenanma neighbourhood in Burma and of the few score wells drilled in the area would solve many of the reviewer's difficulties.

Yours faithfully,

MURRAY STUART
(Member).

London.
November 29, 1926.

To the Editor.

SIR,

As the writer of the review upon Dr. Murray Stuart's little book, I am very sorry to hear that he thinks he has been unfairly treated or misrepresented in any way. I can only suggest that anyone taking an interest in the matter should read the book and the review, and form his own judgment.

Yours faithfully,

E. H. CUNNINGHAM CRAIG.

London.
December 17, 1926.

REVIEWS.

THE SCIENTIFIC PRINCIPLES OF PETROLEUM TECHNOLOGY. By Dr. Leo Gurwitsch, translated and revised by Harold Moore. London. 25s. net. 1926.

The German edition of Dr. Gurwitsch's book is well known to many members of this Institution and many more will welcome the appearance of an English translation by Mr. Harold Moore, who has amplified it by the addition of sections on cracking, on detonation and lubricating oil.

The title of the work is not well chosen and does not give a true indication of the contents. The book deals with few scientific principles and less technology (except where Mr. Moore's additions are apparent). Dr. Gurwitsch is an organic chemist with an extraordinarily wide knowledge of the chemistry of petroleum, its fractions and its constituents and he has dealt with his subject from this standpoint. He makes no attempt to imitate the encyclopædian work of Engler, but he has collected a very large proportion of the work that has been published on the physical behaviour and chemical reactions of the constituents of petroleum and has produced a Treatise on the Chemistry of Petroleum and its Components which should be in the library of every petroleum chemist.

In comparing the book with "Das Erdöl" the reader notices with pleasure that the author has not merely collected other people's assertions but has taken pains to consider and where necessary to criticise the data and opinions he quotes.

The book is divided into four principal sections:—

(1) The Constituents of Petroleum and the action of chemical reagents on them.
(2) The Physical Properties of the Constituents of Petroleum.
(3) The Distillation of Petroleum.
(4) The Refining of Petroleum Products.

The first section is the largest and deals mainly with the effect of chemical re-agents on the constituents of petroleum. The hydrocarbons naturally receive the chief attention, but as the naphthenic acids have been studied to a greater extent in Russia than elsewhere, the oxygenated components naturally receive thorough treatment. The non-sulphurous nature of Russian oil is hardly an excuse, however, for the very inadequate three-page section on sulphur compounds. Much important work on the isolation, characterisation and nature and reaction of these compounds has been published since the distant days when Mabery described the "thiophanes."

The section on the physical properties of petroleum (including an excellent chapter on surface tension and emulsion) is well written and full of interesting and useful information.

The section on distillation deals briefly with the physics of this operation and then passes to a survey of cracking. This survey is made from the chemical rather than from the technical or commercial aspect and deals principally with the effect of experimental conditions on the nature of the product. The more well-known cracking processes are briefly reviewed.

The concluding main section deals with the chemistry and physics of refining, but the chemistry is confined mainly to an account, very exhaustive and informative, of the action of sulphuric acid under all possible conditions on all possible petroleum fractions. Other chemical refining processes are briefly described.

Dr. Gurwitsch's researches on selective adsorption are well known so that the chapter on adsorption and its application to petroleum bears the mark of authority.

This book can be most strongly recommended as reasonable in price and superlative in value.

F. B. Thole.

Investigation on the Treatment of Nova Scotia Oil Shales.

Report No. 18 of the National Research Council of Canada is a piece of work that should be commended to all technologists who take an interest in the low temperature treatment of retortable materials.

Its title is "Investigations on the Treatment of Nova Scotia Oil Shales," but it must be remembered that on the other side of the Atlantic it is the custom to include under the term "oil shales" almost every kind of retortable material. In this case the material is all torbanitic, and no true oil shales are dealt with.

It was the author, Professor A. E. Flynn, of the Nova Scotia Technical College, Halifax, who first separated the gels from the matrix of a torbanite by crushing the material and stirring it in brine of the requisite specific gravity. By this means he floated off the gels, and was able to study and analyse them separately. He was able not only to prove that these gels contain an average of about 18 per cent. of inorganic material, but that the amount of inorganic material varies. In a brine of 1·1 sp. gr. he was able to separate "floats," "suspends" and "sinks" containing respectively 11, 15 and 20 per cent. of inorganic matter; if further proof were necessary, this would be enough to dispose of the claim that these gels are vegetable fossils.

Professor Flynn begins by a study of the raw material, which varies in different seams from the rich so-called "stellarite" to very impure canneloid bands with but a small torbanitic development. The yields of oil, gas and water, and the quality of the oils also vary greatly in the different seams.

A very ingenious experimental retort was designed, so that none of the material could touch the sides and thus become overheated. The retort, a horizontal cylinder of wrought iron, has in its centre a cylinder of 10 mesh screen to contain the raw material. Heat is supplied by eight Bunsen burners. A central ¼ in. pipe is introduced to hold a pyrometer. The condensing arrangements call for no special comment. The retort takes a charge of 700 grams of torbanite in the annular space ¾ in. in thickness between pyrometer tube and screen.

It is evident that with this apparatus it is possible to regulate temperature very accurately, and it is claimed that as an experimental retort it has the following advantages:—

Symmetrical body of raw material.
Quick withdrawal of vapours through central tube.
Long pyrometer tube and thin shale layer, giving small temperature lag and better heat control.
Little opportunity for excessive cracking of vapours.
Can be used on very fast runs.
Cheap, home-made, durable, requiring little bench room, and being easily charged and discharged.

Retorting by such a method may not be calculated to give the very best results from a torbanite, but all kinds of materials can be tested under identical conditions, and the results compared. It is possible, also, to check the retorting at any stage, and remove the material for microscopic examination. This has enabled Professor Flynn to obtain the globules or gels in a torbanite in at least three of the described "stages of deterioration" found in untreated torbanites.

It would be tedious to give an account of all the results in yields of water, gas and oil obtained by Professor Flynn from different materials under different conditions. These are set forth in tables and graphs very clearly, and the effects of slow or fast runs on the yields of saturates and unsaturates and the specific gravity of the oils are also shown.

The effects of retorting with steam are also given for different materials, and it is interesting to note that the ammonium sulphate recovery in one case was reduced from 13·45 lb. per ton to 4·02 lb. by the use of steam.

The Hartman experimental retort was also used in a number of experiments. This is a vertical retort with 10 decks, the raw material being conveyed through the machine by rotating wheel-shaped conveyors on each deck, so that it makes nine circuits in passing through the retort.

However, from the large number of experiments made, a mass of data most interesting to students of retorting practice has been collected, and such data should be of practical importance to anyone engaged in the low temperature treatment of any retortable material, not only torbanites and torbanitic cannels.

The report concludes with a chapter by Mr. R. F. Dimmitt on the refining of Nova Scotia shale (!) oils.

Quite apart from the practical results obtained, Professor Flynn's experiments upon the separated globules from the torbanites are of great scientific interest. He has studied these globules under heat treatment with and without access of air, noting at what temperature the first trace of distillation is noted.

He finds that without access of air:—

At 730° F. traces of mist are noted;
„ 750° F. slight amount of oil;
„ 770° F. oil becomes apparent;
„ 790° F. the globules appear darkened and carbonised, but retain their form;
„ 882° F. slight decrepitation commences;
„ 875° F. a viscous pasty mass is the product.

These temperatures are considerably higher than those at which similar results can be obtained from thin slices of Scottish torbanite. This is, no doubt, partly due to the original gels differing somewhat in nature.

The microphotographs of gels, fresh and partially retorted, are most interesting and are worthy of study, but there is one point upon which some confusion might arise. Professor Flynn states that in a partly retorted torbanite the laminæ are seen "bending round the globules," and that this is generally not observable in sections of untreated torbanite. This is due to the swelling caused by the action of heat: the globules in torbanite do not disturb the lamination.

It can be stated with confidence that the report is of great value both from a scientific and a practical point of view, and it is to be hoped that Professor Flynn will continue his researches and extend them to other materials.

E. H. Cunningham Craig.

L'Activité des Volcans de boue en relation avec la structure des plis gazifères et quelques arguments contre la migration du pétrole. By Dr. Stanislaus Zuber. La Revue Pétrolifère, Paris, 1926. 15 francs.

Diapyr folding is the theme underlying the main discussions on mud volcanoes and oil migration. These discussions are based on the author's observations in the Apsheron Peninsula of the Caucasus.

The three parts of the booklet consist of (1) an introduction; (2) the activity of mud volcanoes; and (3) some arguments of the author's against the migration theory of oil.

The introduction gives a succinct account of diapyr folding, and should prove a useful contribution to that subject. The absence of diagrams and sketches to illustrate the subject is a defect of the book. In the genesis of this type of folding, the author deduces a twofold process, an initial horizontal and a subsequent vertical movement. The result of the first is the shaping of great surface swellings or upheavals, and of the second the formation of longitudinal fractures and faults at the moment of maximum tension. Stratigraphically the normal sequence is found at the edges of the folds, but a more disturbed and irregular state at the centre, where the beds tend to be steeply dipping. Lithologically the more plastic or argillaceous members have been squeezed up into the central core, a fact that has its significance on the formation of mud volcanoes, as the author subsequently points out.

In the part on mud volcanoes, the author points to the relatively insignificant parts played by gas and oil in their formation. He traces the connection of these eruptions with faults traversing the central parts of folds and to diapyr folding in general, to which main cause the genesis of these occurrences may be attributed. In the process of the squeezing up of the core through the more recent formation, the less resistant material, chiefly argillaceous members, is crushed and goes to form the mud breccia, which is eventually ejected in the form of a mud volcano. The beds of water, oil or gas through which the movement may take place would have their influence, although only secondary, as the main cause is tectonical. The author shows a connection, from actual examples, between mud volcanoes and earthquakes, and so with earth movements generally.

In dealing with his anti-migration views of oil deposits, in the last part of the book, the author takes his stand upon his obvervations on the Apsheron oilfields. He points out that actual surface examination and well records present a bewildering array of oil sands, oily clays, water sands in various forms of juxtaposition, the saturation of the sands varying from nil to supersaturation. For this state of affairs, he contends, no migratory theory can account. He thus does not favour the mother-rock theory propounded by Prof. Gubkin as a means for accounting for the genesis of the Caucasian oil deposits. The difficulty in doing so, he considers, becomes accentuated when it is a question of dealing with a Continental series of deposits like those of the productive series of Apsheron and Cheleken. The author sums it up in the words "neither tectonics, nor lithology, nor even calculations, gives us any data in favour of an original source of oil for the Baku deposits."

Those who have had to do with the Russian oilfields will hardly be inclined to accept the author's deductions in this matter in their entirety, and Mr. T. G. Madgwick's paper on the Russian oilfields in the records of this Society has bearing on this.

The author is also inclined to take the case of the Apsheron Peninsula, not as isolated, but as typical, basing his contention on the facts of the Caspian deposits being the most recent, the structure simple and the data abundant. This probably is where issue may again be joined with the author, as the Baku facies appears to be local and difficult of correlation with the Neogene formations in other parts of the Caucasus.

F. G. Rappoport.

BOOKS RECEIVED.

REPORT OF TEST BY THE DIRECTOR OF FUEL RESEARCH ON THE "FUSION" ROTARY RETORT INSTALLED AT THE WORKS OF ELECTRO-BLEACH AND BY-PRODUCTS, LTD., CLEDFORD, CHESHIRE. H.M. Stat. Office, London, 1926. 9d. net.

Describes tests carried out in July, 1925, on a small commercial retort of 5 tons daily capacity, the material used for the test being Welbeck Cannel. The total yield of tar and oils was 50.23 gals. per ton of coal, the gas yield being 2740 cu. ft. or 29.3 therms per ton. The crude spirit obtained from the gas amounted to 3.75 gals. per ton of coal.

ART DE L'INGENIEUR ET METALLURGIE. RESISTANCE DES MATERIAUX ET DONNEES NUMERIQUES DIVERSES. Arranged by L. Descroix. Gauthier-Villars et Cie, Paris, 1926.

In writing the preface to this work, which is extracted from Vol. V., 1917-1922, of "Tables Annuelles de Constantes et Donnees Numeriques," Sir Robert Hadfield, Bart., F.R.S., says:—"As a Metallurgist I regard these Tables of Annual Constants of great importance, published too as they are under the patronage of the following Technical Societies: the Iron and Steel Institute, the Institute of Metals, the Council of Scientific and Industrial Research, the American Institution of Mechanical Engineers, the Comite des Forges, and the Societe d'Encouragement pour l'Industrie Nationale. The information presented is undoubtedly of great service to scientific and practical workers in these branches of Science."

A NOTE UPON THE OBLIGATION OF THE IRON-FOUNDER TO DIESEL ENGINE USERS. Horace J. Young, F.I.C. Diesel Engine Users' Association London, 1926. 5s.

A paper read before a meeting of the Diesel Engine Users' Association on October 15th, 1926, together with a report of the discussion thereon.

REPORT ON HEAVY-OIL ENGINE WORKING COSTS (1925–1926). Diesel Engine Users' Association, London, 1926. 5s.

The report, dated November, 1926, of the General Committee of the Diesel Engine Users' Association and dealing with the Working Costs of Diesel Engines for the period 1925–1926. Figures relating to 37 Home and 9 Overseas Stations, with a total of 177 engines and generating 59,852,763 units, are given.